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DISTRIBUTION AND HOSTS OF CERTAIN NORTH AMERICAN TICKS

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The importance of ticks as transmitters of a number of serious diseases and as parasites and annoyers of man and animals makes desirable the assembling of information on their geographical and seasonal distribution, and especially on their host relationships.

During the last 35 years representatives of the Bureau of Entomology and later the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, have collected specimens of ticks from many parts of the United States, and with the aid of correspondents have assembled numerous lots of these parasites with appropriate collection data.

The identifications have for the most part been made or verified by the senior author. A great many of the specimens collected in the earlier years of this period were determined by Nathan Banks, and some by W. A. Hooker and the late H. P. Wood. During this long period many individuals participated in the collection of specimens, in the accessioning and care of material, and in the rearing of some of the immature stages. This assistance is gratefully acknowledged, and the writers regret that it is not practicable to give specific credit to all those who have given assistance, but mention is made of the following whose contributions are especially noteworthy: W. A. Hooker, W. V. King, Harold S. Peters, George N. Wolcott, and Carroll N. Smith.

Although the formal data presented are based entirely on the collections of the Bureau of Entomology and Plant Quarantine, reference is made here and there to distribution and host records not represented in the Bureau files. Maps are used to indicate distribution of the more important and numerous species. The large dots in these maps represent specific points from which ticks in the Bureau collection were taken. Although distribution of these large dots is indicative of abundance, consideration must be given to the fact that more intensive collecting was carried out in some areas than in others. The small dots indicate the probable normal distribution of the species. This probable distribution takes into consideration records published by others than members of the Bureau staff.

Considerable information on the distribution and hosts of a number of North American ticks has been published by Hunter and Hooker (1907), Banks (1908),

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Hooker (1908, 1909a, 1909b), Hunter and Bishopp (1911), Cooley (1911), Bishopp (1911a, 1911b, 1912), Birdseye (1912), Hooker, Bishop, and Wood (1912), Bishopp and King (1913), Bishopp and Wood (1913), Chamberlain (1937), and Cooley (1938). The data in the above publications that had been taken from the records of the Bureau of Entomology and Plant Quarantine are included in the present publication. Many others have published data in this field and some of these are referred to under the various species.

No effort has been made to list all known hosts or to present complete informa-

TABLE 1.—Amblyomma americanum: *Host Records of the Bureau of Entomology and Plant Quarantine*

Host	Lots	Larvae	Nymphs	Males	Females
No host or unattached	56	1(−100)*	20(64)	36(164)	38(+123uf)
Badger	1	.....	.....	1(1)	1(1u)
Bobcat (*Lynx rufus* and *L. r. floridanus*)	2	.....	2(7sp)	.....	1(2s)
Cardinal	1	.....	1(1)	.....	.....
Cat (domestic)	3	.....	3(17)	.....	.....
Cattle	124	9(+36uf)	44(+289uf)	58(+225)	78(+450uf)
Chaparral cock	5	3(77pf)	.....	.....	.....
Chicken	1	.....	1(1s)	.....	.....
Coyote	1	.....	.....	1(1)	1(9)
Crow, southern	1†	.....	.....	.....	.....
Deer, white-tailed	20	15(215uf)	44(523uf)	35(+402)	34(129uf)
Dog	106	13(+52uf)	33(145uf)	45(+205)	74
Fox, gray and Florida gray	11	6(118uf)	6(32up)	4(6)	1(1s)
Goat	18	1(2f)	7(161sf)	8(+12)	14(65sf)
Hawk, sparrow	1	1(1f)	.....	.....	.....
Heron, little green	1	.....	.....	1(1)	.....
Hog	30	1(12)	15(78uf)	22(186)	22(203up)
Horse	26	1(2)	8(39uf)	14(119)	22(+146uf)
Lion, mountain	1	.....	1(1p)	1(1)	1(2s)
Man	159	12(+145u)	98(+319up)	82(+314)	67(+328uf)
Mink, Florida	1	1(1u)	.....	.....	.....
Mule	7	.....	8(26uf)	5(+58)	6(+80uf)
Opossum, Florida	2	.....	2(3us)	.....	.....
Oven bird	1	1(1f)	.....	.....	.....
Pocket-gopher, southern	1	.....	1(3sp)	.....	.....
Quail	6	3(59us)	5(17up)	.....	.....
Rabbit	1	1(8u)	.....	.....	1(2u)
Rabbit, Carolina marsh	2	.....	2(2us)	.....	.....
Rabbit, jack	1	.....	1(1f)	1(1)	.....
Rabbit, swamp	1	.....	1(5sp)	.....	.....
Raccoon (several forms including *Procyon lotor elucus* and *P. l. solutus*)	14	8(220uf)	10(313uf)	.....	1(1)
Rat, eastern cotton	1	1(1)	.....	.....	.....
Rat, Norway	1	1(1f)	.....	.....	.....
Rat, rice	1	.....	1(1s)	.....	.....
Sheep	10	.....	.....	5(12)	10(+47uf)
Skunk (several species including Florida skunk)	5	1(21)	4(+17uf)	.....	.....
Squirrel (several species including fox, southern fox, western fox (introduced), red, rock, and gray)	15	7(70uf)	14(+126uf)	.....	1(1)
Squirrel, southern gray	16	10(37uf)	12(31up)	.....	.....
Turkey, wild	8	3(22uf)	7(49up)	.....	.....
Wolf (several species including red)	4	1(1p)	1(3f)	.....	1(5f)
Woodchuck, southern	1	.....	1(21pf)	.....	.....
Yellowthroat, Florida	1	.....	1(1u)	.....	.....

* See text for significance of figures and symbols.
† 3 ticks the stage or stages of which were not recorded.

tion on the world distribution of the species treated. Some general idea of distribution outside the United States is given, however, for most species. In presenting the host data the number of the different hosts examined was not the same and other factors make direct comparisons difficult; however, the number of times a species was taken on a given host appears to give some slight indication of the relative importance of different animals as hosts for a tick species.

In the tables which give the hosts of the various ticks, the following method of indicating the collection data has been adopted to permit condensing of the informa-

tion. The number of separate lots is given in the first column following the name of the host. In the columns that follow, the first number gives the number of lots that included the stage at the head of the column, in parentheses is given the number of individuals, usually with an indication of the state of engorgement, in which case "u" signifies unengorged, "s" slightly engorged, "p" partly engorged, and "f" fully engorged. Thus in Table 1, in the data for man there were in the collections 159 lots, 12 lots included more than 145 unengorged larvae, 98 lots included more than 319 unengorged to partly engorged nymphs, 82 lots included more than 314 males, and 67 lots more than 328 unengorged to fully engorged females. Data that could not be exactly classified are given in footnotes. Males of ixodid ticks do not become distended, and so no degree of engorgement is indicated for species of that group.

Hosts are referred to by common names, and a list of scientific names is given at the conclusion of the article.

Amblyomma americanum (L.)

The Lone Star Tick

The lone star tick is among the more economically important species in the United States. As a parasite it is important because of the fact that it attaches to man in all its active stages, and because its long mouth parts are deeply embedded in the host and often broken off when the tick is removed, thus producing persistent and severe irritation. Its great abundance on various wild and domestic hosts causes much annoyance and loss of blood. This species is also a predisposing cause of screwworm attack. As a disease carrier it assumes importance since it is capable of transmitting tularemia and Rocky Mountain spotted fever. In the South this species probably plays a larger part in this respect than is recognized. Recently the occurrence in nature has been reported of nymphs infected with the causative organism of American Q fever (*Rickettsia diaphorica*) in Liberty County, Texas.

Distribution

This tick is abundant in the States bordering the Gulf of Mexico. It is plentiful along the South Atlantic coast and in parts of Oklahoma, Arkansas, and Missouri. Occasional specimens are collected in States to the North. There is much local variation in the abundance of this tick. It is to be found in especially great numbers in wooded areas, particularly where underbrush is dense, such as along river-bottoms in prairie areas, and in the canebrakes of Louisiana and Mississippi. This tick has become notoriously abundant in the Ozark region in recent years, and the collection of specimens on several different dates at Osceola, Iowa, by one of our collaborators, G. S. Cantonwine, indicates that the species is well established there.

Its present occurrence in the more northern States such as Connecticut and Michigan is probably accidental, resulting from introductions on people or domestic animals. The single record (1 unfed female on dog) from Chicago, Ill., might be attributable to the livestock trucks which the dog's owner says pass the house. An unfed female from Labrador is in the Marx collection. The species has been recorded from Guatemala, "Guiana," and Brazil and undoubtedly occurs in the Gulf Coast region of Mexico.

Fitch (1872) stated that although the lone star tick was formerly common in New York State, he had seen only a single specimen from there—one collected in 1830. There is reason to believe that this species was more numerous in the Northern States many years ago. Cooley and Kohls (1944a) have presented a number of detailed records of collections. These do not extend the distributions beyond that indicated by our collections as shown on the map in Fig. 1.

The type locality is Pennsylvania or New Jersey.

Hosts

The lone star tick is a three-host species, and is a general feeder in all its active stages. Our records indicate that certain ground-inhabiting birds, such as quail and wild turkey, are commonly infested with larvae and nymphs, yet there is no evidence of domestic turkeys, chickens, or other poultry being heavily infested. This

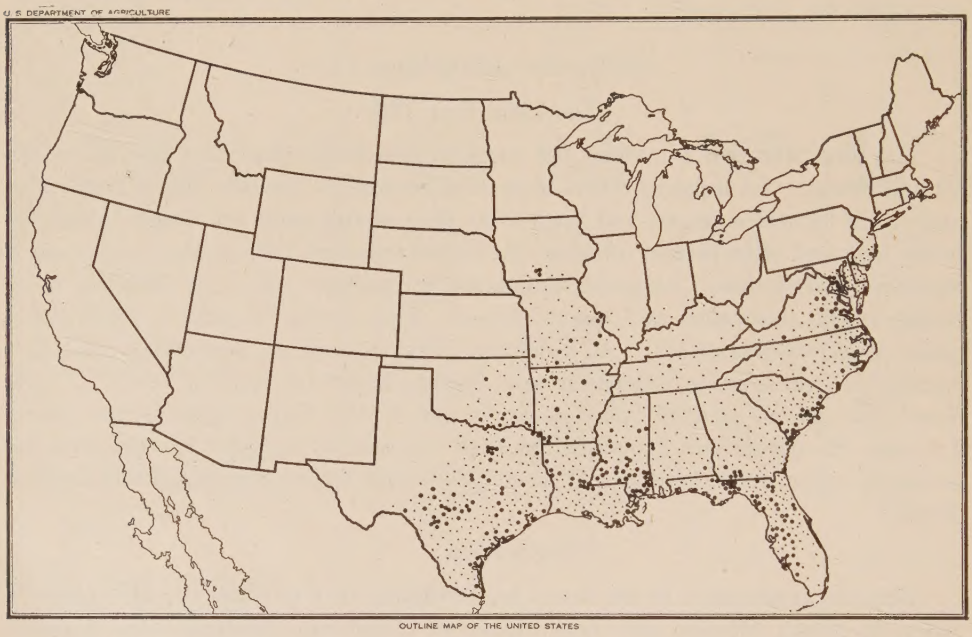

FIG. 1. Distribution of *Amblyomma americanum* in the United States. Large dots indicate localities from which specimens are herein reported. Small dots indicate probable distribution of species.

is probably due mainly to lack of exposure of these hosts in heavily infested areas. It is interesting to note that wild turkeys on Bull's Island, S. C., have been observed by Messrs. Blakey and Baldwin to be very heavily infested with larvae and nymphs. In fact, there is some reason to attribute mortality of wild turkeys to gross infestations of this species. Rabbits, for some reason, appear rarely to be infested. Deer are often very heavily infested with all stages. The authors have observed specimens of Virginia deer that were literally covered with larvae, nymphs, and adults in various stages of engorgement. The ears, both inside and outside, are favorite places of attachment.

A careful estimate was made of the number of ticks on 1 ear of a deer at Mt. Pleasant, S. C., in September 1937. There were approximately 4,800 specimens, most of which were nymphs of *Amblyomma americanum,* although a few males

of *A. americanum* and a few females of *A. maculatum* were present. The other ear was also heavily infested. The ears under such circumstances become thickened, scabby, and partly denuded of hair. The ticks also attach to and engorge on the antlers when these are in the velvet.

In the Southern States this tick has been taken in all stages on hosts throughout the year, although it is less abundant during midwinter.

Host records of the Bureau of Entomology and Plant Quarantine are given in Table 1.

Amblyomma cajennense (F.)

The Cayenne Tick

The cayenne tick is a native of North, Central, and South America. The first collection and type material of this species came from Cayenne, French Guiana. It is a species of much economic importance in the tropics of the Americas, where it is generally abundant and active the year round. It has been shown to be a carrier of Rocky Mountain spotted fever in Brazil, and it is a very troublesome pest of man and of all classes of livestock.

Distribution

Distribution of this tick in the United States appears to be confined to extreme southern Texas (Fig. 2). The Marx collection contains an unengorged female

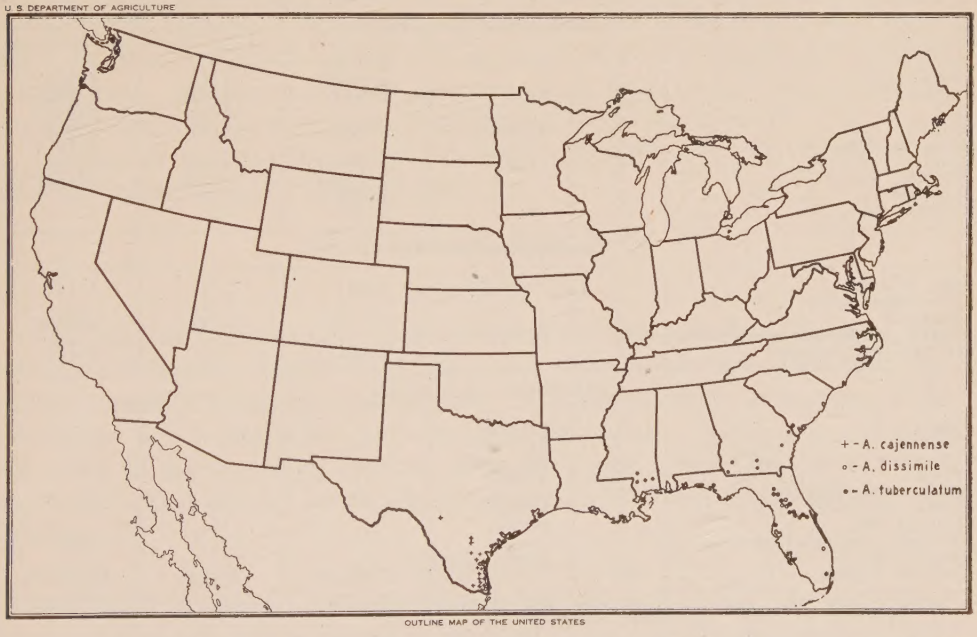

FIG. 2. Distribution of *Amblyomma cajennense, A. dissimile,* and *A. tuberculatum* in the United States, as indicated by collections of the Bureau of Entomology and Plant Quarantine.

labeled "Biscayne Bay, Fla."; however, this species does not appear to be established in that State. As pointed out by Hooker, Bishopp, and Wood (1912), records of the occurrence of this tick in Arizona are probably based on a jar of ticks incorrectly labeled. A collection from San Diego County, Calif., is recorded by Banks (1908). The collection of the Bureau of Entomology and Plant Quarantine includes speci-

mens from the following counties in Texas: Aransas, Cameron, Hidalgo, Jim Wells, Kennedy, Kleberg, Liveoak, Nueces, Uvalde, and Willacy. It also contains specimens from Mexico, Cuba, Jamaica, Guatemala, Honduras, Panama, Colombia, Venezuela, and Brazil. Other countries from which this tick has been recorded are the following: Nicaragua, Costa Rica, Bermuda, Trinidad, French Guiana, Paraguay, and Argentina. Cooley and Kohls (1944a) record specimens from two additional southern Texas counties, Starr and Brooks.

Hosts

All stages of this species attach to man as well as to livestock; and the long mouth parts make removal difficult, often breaking off to remain in the flesh and cause painful wounds. In many parts of tropical America the larvae and nymphs are extremely abundant and aggressive in attacking man. All stages are active and are found on hosts throughout the year. Their small size and activity make their exclusion from clothing very difficult.

Bureau of Entomology and Plant Quarantine records from the United States are given in Table 2.

TABLE 2.—Amblyomma cajennense, A. dissimile, *and* A. tuberculatum: *Host records of the Bureau of Entomology and Plant Quarantine*

Host	Lots	Larvae	Nymphs	Males	Females
		Amblyomma cajennense			
Ass	2	....	2(2uf)	....	....
Cattle	5	....	2(28uf)	1(1)	4(4up)
Coyote	3	1(3p)	3(9sp)	2(5)	1(2us)
Dog	3	....	....	1(2)	3(5up)
Horse	9	1(1sp)	2(23f)	6(9)	8(9uf)
Lion, Mexican	1	....	....	....	1(1s)
Man	6	1(1p)	3(10uf)	1(1)	3(3u)
Peccary, Texas	7	....	5(19sp)	5(13)	4(7uf)
Raccoon	1	....	1(3up)	....	....
Turkey, wild	1	....	1(3p)	....	....
		Amblyomma dissimile			
Boa, Mexican	2	....	1(1s)	1(1)	1(1s)
Ctenosaura, spiny	1	....	....	1(1)	....
Iguana	6	....	3(27p)	6(41)	3(23uf)
Lizard (*Scaloporus undulatus*)	1	1(15pf)	....	....	....
Rattlesnake, diamond	2	....	1(5pf)	....	1(1f)
		Amblyomma tuberculatum			
Cattle	1	1(3up)	....	....	....
Chicken	1	1(10uf)	....	....	....
Dog	7	7(+89uf)	....	....	....
Hawk	1	1(6uf)	....	....	....
Meadowlark, southern	1*	....	....	....	....
Rabbit, cottontail	1	1(75)	....	....	....
Squirrel, fox	1	1(75)	....	....	....
Terrapin, diamond-back	1	....	....	....	1(1)
Thrush, hermit	1	1(1f)	....	....	....
Tortoise, gopher	28	....	13(65up)	21(52)	13(27uf)

* Recorded as "tick." No stage indicated.

Horses and mules in the vicinity of Tampico, Mexico, were noted by the senior author to have numerous males and females of this species attached to them.

Foreign records include the following hosts: Game cock, burro, cattle, deer, dog, horse, and man.

Amblyomma dissimile Koch

The Iguana Tick

The iguana tick is of no known economic importance, although in some instances it may be injurious to reptiles in captivity.

Distribution

The iguana tick is a native of tropical America, ranging from Mexico and the West Indies to Argentina. The type locality is Mexico. Our collections do not contain any specimens taken in nature in the United States, but specimens are not infrequently seen on reptiles and amphibians in zoological gardens, especially in localities where such animals are first brought in from the Tropics (Fig. 2).

Bequaert (1932) reports a collection from a snake in nature at Boca Raton, Palm Beach County, Fla., and Sebastian, Indian River County, Fla.

Outside the United States, the species is recorded from Mexico, Guatemala, British Honduras, Republic of Honduras, Nicaragua, Costa Rica, Panama, Colombia, Venezuela, Peru, British Guiana, Brazil, Paraguay, Argentina, Tobago, Grenada, Saint Lucia, Antigua, Barbados, and Jamaica.

Hosts

This species attaches exclusively to cold-blooded animals (Reptilia and Batrachia) in nature, although, as reported by Hooker, Bishopp, and Wood (1912), it has been engorged in the larval and nymphal stages on bovines. These authors were unable to get the adults to attach to warm-blooded animals. Robinson (1926) also lists adults as having been taken from cow (1 lot) and sheep (1 lot), and Neumann (1911) lists capybara as a host. Newstead (1909) states that in Jamaica it is apparently confined to the toad *Bufo marinus* and that on this host it often occurs singly, but that occasionally four or five specimens of various stages were found on a single host. Bequaert's (1932) specimens were from gopher snake (*Spilotes corais cooperi*) and pigmy, or ground rattlesnake (*Sistrurus miliaris*).

The records of hosts of the iguana tick (all in captivity) in the Bureau collections from the United States are shown in Table 2.

Amblyomma maculatum Koch

The Gulf Coast Tick

The Gulf Coast tick is a rather important pest of livestock in the States bordering the Gulf of Mexico. The adults attach in the external ears and when numerous produce intense inflammation and swelling. This often induces infestations of the screwworm, which may result in the death of the animal. It may also cause the destruction of the supporting cartilage of the ears, especially in the case of horses and mules. This permits the ears to droop over, a condition popularly known as "gotch ear."

Distribution

This tick is a native of North, Central, and South America. In the United States its distribution is restricted to the Gulf Coast and Coastal South Atlantic regions from South Carolina to Texas, inclusive (Fig. 3). It is most abundant in the area within 100 miles of the coast. A few specimens have been collected at interior points, such as at Dallas, Tex., Memphis, Tenn., and East Saint Louis, Ill. Those taken in the last two localities were probably all shipped in on livestock as at least some of them were on cattle that had been received recently from coastal areas. However, we received from Chapman and Bernard, Tulsa, Okla., a collection of 7 males and 7 females of the Gulf Coast tick taken from horses and cattle

on their ranch near Tulsa on June 22, 1944. They stated that this is the first time this tick has been noticed in the locality and yet it is very prevalent this year and getting into the ears of cattle and horses. No livestock had been shipped into the locality from the Gulf Coast area. They comment that there has been an unusual amount of rain in March and April, which may have something to do with the appearance of this pest. When the duration of attachment of the males and the fact that the larvae and nymphs often engorge on migratory birds is considered, it is surprising that more ticks of this species have not been found north of the normal range.

Niles (1898) collected ticks in Virginia in 1898 which were referred to as *Dermacentor occidentalis,* but Prof. H. A. Morgan has pointed out that these were

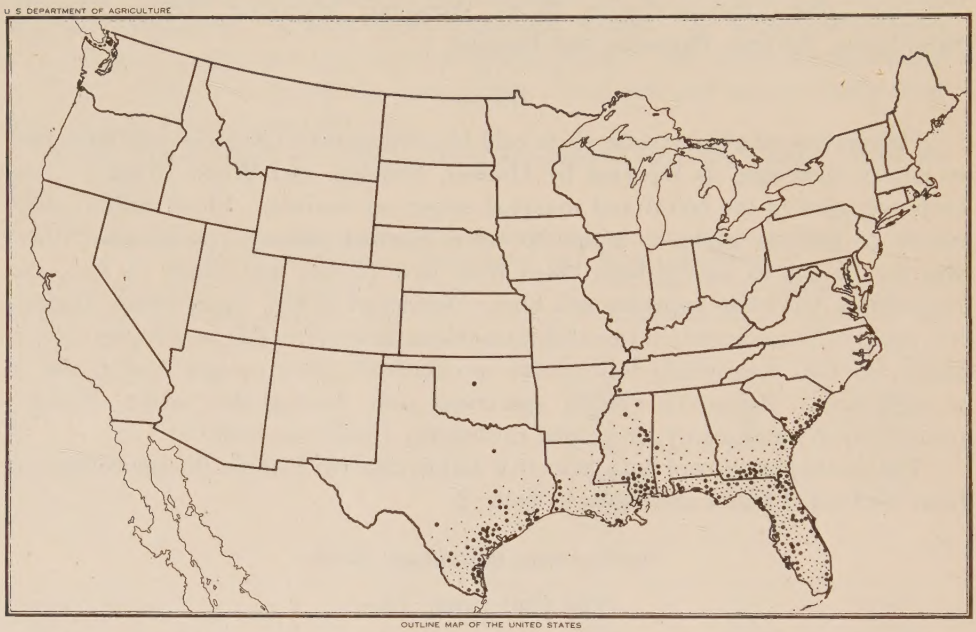

FIG. 3. Distribution of *Amblyomma maculatum* in the United States. Large dots indicate localities from which specimens are herein reported. Small dots indicate probable distribution of species.

Amblyomma maculatum. The Marx collection contains a male specimen labeled by Marx "Tulare Co., Calif." This was probably an introduction on a host, as was probably the Virginia specimen. Cooley and Kohls (1944a) record two collections, similarly out of range, from Willcox, Ariz., and Weathers, Okla. Certainly this species is not common north of South Carolina.

The tick is known to occur abundantly along the Gulf Coast in Mexico and has been collected in Jamaica, Colombia, Brazil, Paraguay, Uraguay, Patagonia, Ecuador, Peru, and Chile.

The type locality is "Carolina."

Hosts

The Gulf Coast tick is a 3-host species. The larvae and nymphs engorge mainly on ground-inhabiting birds, although they are found not infrequently on small mammals. On birds they attach chiefly around the head. As many as 289 larvae have been taken on a single meadowlark (Bishopp and Hixson, 1936). On

October 26, 1937, a total of 152 ticks were taken by H. M. Brundrett from a meadowlark at Penny Farms, Fla. Of these, 98 were larvae of *Amblyomma maculatum* and others were *Haemaphysalis chordeilis* and *H. leporis-palustris*. Sheep, mules, horses, and cattle, in about the order named, suffer most from attack of the adults.

The adults are seldom found on hosts in the United States during the late winter and spring. They increase rapidly after the middle of July and become most abundant in late summer and early fall. Immature stages are found on birds throughout the year, but are less abundant in winter.

TABLE 3.—Amblyomma maculatum: *Host records of the Bureau of Entomology and Plant Quarantine*

Host	Lots	Larvae	Nymphs	Males	Females
Cloth dragged over vegetation	15	2(3u)	....	8	11(+uf)
Bear	1	....	....	1(1)	....
Blackbird, Brewer's	1	....	1(1f)	....	....
Blackbird, redwinged	2	....	2(3pf)	....	....
Bluebird	1	....	1(1s)	....	....
Bobcat	1	....	....	1(1)	....
Cardinal	2	1(1)	1(8)	....	....
Cat, domestic	2*	....	....	1(1)	....
Cattle	75	....	....	53(+271)	55(+131uf)
Cowbird	1	1(1)	1(10sp)	....	....
Coyote	1	....	....	....	1(1s)
Deer, white-tailed	19	....	....	15(55)	8(+9)
Dog	38	....	....	31(+59)	22(+52uf)
Fox, gray	2	....	....	1(2)	1(3pf)
Goat	3	....	1(1)	2(13)	2(17up)
Grackle	2	....	2(3pf)	....	....
Hog	12	....	....	8(13)	11(22uf)
Horse	18	....	....	12(+25)	14(+42uf)
Killdeer	1	....	1(1s)	....	....
Man	4*	....	....	1(1)	2(6u)
Meadowlark	72	19(+170uf)	65(+123uf)	....	....
Mockingbird	2	2(8sp)	....	....	....
Quail	4	1(30sf)	3(9sf)	....	....
Rabbit, cottontail	2	....	2(7sf)	....	....
Rabbit, jack	1	....	1(6s)	....	....
Raccoon	1	....	1(1u)	....	....
Rat, cotton	1	....	1(1f)	....	....
Rat, rice	1	1(50f)	....	....	....
Sheep	23	....	....	13(+42)	19(+119uf)
Skunk	1	....	....	....	1(1u)
Sparrow, Bachman's	1	....	1(2sp)	....	....
Sparrow, Florida grasshopper	2	....	2(6f)	....	....
Sparrow, swamp	1	....	1(1p)	....	....
Squirrel, fox	2	....	2(4)	....	....
Thrush, wood	1	....	1(1f)	....	....
Towhee (several species, including red-eyed and white-eyed)	5	4(+11pf)	2(+1s)	....	....
Warbler, palm	1	1(9f)	....	....	....
Wolf	1	....	....	1(2)	1(1u)
Woodpecker, red-bellied	1	....	1(1s)	....	....
Wren, Carolina	2	2(+)	....	....	....
Wren, short-billed marsh	2	....	2(2p)	....	....

* 1 lot labeled "ticks."

Bishopp and Hixson (1936) record collections in Georgia of larvae from the following hosts not listed above: bluejay, *Cyanocytta cristata cristata;* mockingbird, *Mimus polyglottos;* migrant shrike, *Lanius ludovicianus;* gray squirrel, *Sciurus niger niger;* cotton rat, *Sigmodon hispidus hispidus;* and sheep. A nymph was also recorded by them from the Carolina wren. These authors record the rearing of larvae, under laboratory conditions, on the following hosts: Junco (*Junco hyemalis*), guinea pig, meadowlark, pine mouse (*Pitymus pinetorum pinetorum*), white-footed mouse (*Peromyscus maniculatus*), quail, or bobwhite, cotton rat, roof rat, English sparrow, woodpecker (*Centurus carolinus*), and pigeon.

Hosts of this tick recorded from Mexico, the West Indies, and South America include the following: *Corvus campestris, Podinoma teguixin, Canis azarae,* and *C.*

griseus. Nymphs are reported by Aragão (1911) from *Nothura maculosa* (?) and *Rhynchotus rufescens*.

Host records of the Bureau of Entomology and Plant Quarantine are given in Table 3.

Amblyomma tuberculatum Marx

The Gopher-Tortoise Tick

The gopher-tortoise tick is of little economic importance because its principal host is the land tortoise, *Gopherus polyphemus,* so abundant in Florida. With perhaps one exception, *Amblyomma varium,* this is the largest species of tick known. The engorged female attains a length of 18 to 24 mm., and the engorged nymphs, 8 to 10 mm. In a few instances the larvae have been found to be annoying to chickens as a result of attachment in considerable numbers.

Distribution

The gopher-tortoise tick has been reported only from Florida and Alabama by Hooker, Bishopp, and Wood (1912), and from Cuba by Neumann (1899). It is rather abundant in central Florida, but much less so in western Florida and the southern parts of Alabama, Georgia, Mississippi, and South Carolina. Its distribution is approximately co-extensive with that of the gopher-tortoise (Fig. 2).

The species is apparently rare in the West Indies. Tate (1941) has examined many specimens of cold-blooded animals in Puerto Rico without finding it. The record from Cuba by Neumann referred to a single male (Gundlach coll. Paris Mus.).

Hosts

Adults of the gopher-tortoise tick confine their attack to the common land tortoise of the Southeastern States and the West Indies. They attach for the most part to the softer parts of the animal, as around the legs, tail, and neck, but not infrequently are found on the edge of the shell. This is particularly true of the males, which remain on the host long after the females become engorged and drop. It is probable that the adults never feed on warm-blooded animals. They have been engorged on box tortoise (probably *Terrapene ornata*) according to Hooker, Bishopp, and Wood (1912, p. 125).

The land tortoise is the principal host of the nymphs. In fact, our collection records fail to reveal their presence on any other animal in nature. However, they have been engorged on bovines under laboratory conditions.

The larvae feed on warm-blooded animals and birds, and they may occur on chickens, as previously stated, in considerable numbers. They have never been taken on cold-blooded animals by the writers.

The adults have been taken on the host throughout the year, and the records on larval collections indicate that they are probably present on hosts the year round, although our collections were made mainly during the cooler months, especially in December.

A list of the host records based on material examined by us is given in Table 2.

Argas miniatus Koch

The Fowl Tick

The fowl tick is a poultry pest of first importance in the Southwestern States, and in many places in warm-temperate, subtropical, and tropical countries of the

globe. This tick not only transmits fowl spirochaetosis, but it causes a form of paralysis among fowls and is a source of heavy loss to poultry raisers through the irritation and loss of blood due to its feeding on fowls of all ages. It is usually associated with domestic fowls, but it may be abundant in the roosting places of colonies of such wild birds as turkeys and vultures.

Distribution

As indicated above, this tick is widely distributed in the warm-temperate and tropical parts of the world. It is much less important as a pest in the more humid regions than in the arid sections, and its northern distribution in the United States is very definitely limited by low temperatures (Fig. 4). Although specimens have

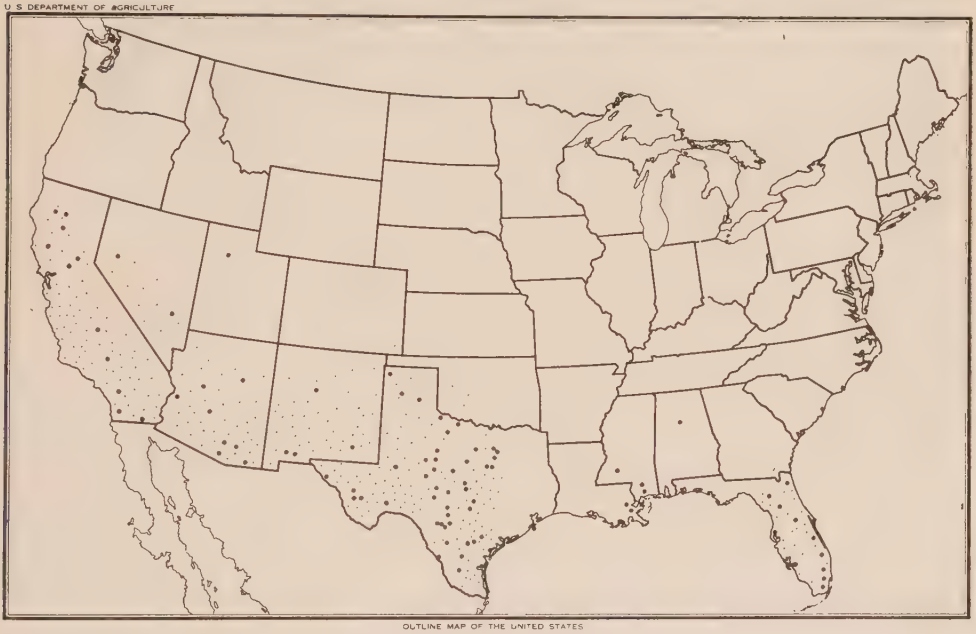

FIG. 4. Distribution of *Argas miniatus* in the United States. Large dots indicate localities from which specimens are herein reported. Small dots indicate probable distribution of species.

been collected as far north as Iowa, and Portland, Ore. It appears that extreme northern records were based on introductions which did not persist. Hearle (1938) reported the identification of four nymphs collected (probably as larvae) on the golden-crowned sparrow at Vancouver, B. C., on May 2, 1931. He concluded that the bird had probably picked up the infestation in a chicken yard in California. During the last 40 years this tick has spread considerably through the Southern States, although it has not become generally distributed in the regions of heavy rainfall except in Florida. Dr. Clay Lyle has written us that the fowl tick does not occur in Mississippi except where it is introduced on poultry grown in the West. He states, "In addition to Biloxi it has been found in Wiggins, Brookhaven, and Meridian. The Wiggins infestation was reported June 22, 1935, and the Brookhaven infestation October 13, 1943. In all cases efforts have been made to eradicate the infestations as soon as possible."

Hosts

Domestic fowls are by far the most important hosts of *Argas miniatus,* and chickens and turkeys are more frequently and more heavily infested than ducks or geese. Apparently the habits as well as the nature and density of the feathers tend to give ducks, geese, and pigeons much freedom from attack. Wild birds found infested were usually rather closely associated with poultry. Vultures may be somewhat of an exception to this, although vultures frequent barnyards and slaughter pens and may easily pick up infestations of seed ticks in such places and carry them to their roosts to become established. In two instances in which vulture roosts were investigated, the trees in which large numbers of the birds roosted were all infested with the tick in various stages of development. Under the bark and in crevices of one tree literally thousands of the ticks were present.

Reports of the fowl tick annoying man and livestock have been received, but it is evident that mammals are not preferred hosts. In most occurrences of this kind, poultry were, or had been, kept in close association with man or the animals annoyed. In one case in California a family that had made its home temporarily in a chicken

TABLE 4.—Argas miniatus: *Host records of the Bureau of Entomology and Plant Quarantine*

Host	Lots	Larvae	Nymphs	Males	Females
Dog*	1	....	1(1)	....	1(1)
Dove	1	1(13pf)	....	....	....
Duck, domestic	1	1(8p)	....	....	....
Hawk, Swainson's	1	1(1p)	....	....	....
Man	2	....	†	†	†
Quail	2	(12sf)	....	....	....
Quail, California valley	1	1(6sp)	....	....	....
Thrush	1	1(2f)	....	....	....
Turkey, domestic	2	1(21uf)	....	1(2)	1(2)
Turkey, wild	2	2(8up)	....	....	....
Vulture (turkey and black)	3	1(1s)	Many	Many	(+150uf)

* Ticks were submitted by a correspondent, who said they were from a dog.
† Number and stage unknown.

house reported that the ticks were biting them and causing much annoyance. One nymph was sent in from Calexico, Calif., with the report that it was biting man in bed and produced "an angry swelling with a white center."

The writers have a few other records of this tick attacking man, but these were instances in which poultry was closely associated with human habitations. Furthermore, the extent to which they actually insert their hypostomes into man, or draw blood, in the cases mentioned above, or others, has not been clearly established. The senior author, in working with this tick in all stages for a number of years, has never observed any tendency for it to attack man. This tick is called the "Miana bug" in Persia, and it is purported to be a pest there of man; however, it is likely that *Ornithodoros,* which bites man freely, may be confused often with the fowl tick.

Statements have been made by farmers that this tick annoys horses stabled in buildings in which chickens have roosted. Whether the ticks bite the horses or annoy only by crawling on them has not been established. Hooker, Bishopp, and Wood (1912) record the J. D. Mitchell collection of 3 adults on a jack rabbit in Texas. There appears to be a possibility that two lots of specimens may have been confused when this collection was made. These authors failed to get larvae confined on a bovine to attach, and were unable to get them to engorge on pigeons.

They partially engorged a single adult on a guinea pig. Nuttall and Warburton (1908, p. 84) obtained engorgement on rats and mice, but with difficulty.

Of 170 collections recorded in the Bureau accession files, 153 are from chickens or poultry houses. Other collections are shown in Table 4.

Dermacentor albipictus Pack.

The Winter Tick

The winter tick is a pest of importance on horses, cattle, and certain wild animals, especially moose and elk. Horses, particularly colts, on the range are often so heavily infested as to be weakened or even killed by it. Moose and elk die from gross infestation combined with feed shortages in late winter and early spring. There is some evidence that this tick is capable of transmitting Rocky Mountain spotted fever, although it can be of little importance in this respect because of its restricted host relations.

This is a one-host species, the larval and nymphal molts being passed on the host. Its seasonal activity is confined to the late fall, winter, and spring, when infestations are easily overlooked in the long winter coats of animals. When feed is short, the injurious effects are intensified.

Distribution

The winter tick is widely distributed in the Northern and Western States and in Canada (Fig. 5). It undoubtedly occurs in northern Mexico. The species is very unevenly distributed within its normal range. It appears to reach maximum abundance in the extreme northern States from Maine to Washington and Oregon. It is considered by Hearle (1938) to be one of the commonest and most widespread of Canadian species.

If *Dermacentor nigrolineatus* is regarded as a synonym of *D. albipictus* or as a variety of that species the distribution is extended to all parts of the United States. The senior author has been inclined to this view since the collection of forms in western Texas in 1921 that were intermediate between the extremes described by Packard. Cooley (1938) regards the species as synonymous. In this article, however, we are treating the forms as distinct species.

The tick remains on a host for 1 to 2 months, which gives abundant opportunity for its shipment from one part of the country to another. For instance, there are records of its shipment on elk from northern Wyoming to northern Colorado, and on a horse from Capitan, N. Mex., to Pocohontas, Miss.

Hosts

This tick is commonly found on the larger domestic and wild animals. It appears to prefer horse, elk, and moose, but is often abundant on cattle and deer. The seasonal occurrence on hosts varies somewhat with latitude and altitude. It is seldom found on hosts in the fall earlier than the end of September or in spring later than early June. For instance, adults have been collected in Los Angeles County, Calif., October 6, 1932, and in Badlands, N. Dak., on June 3.

Collection records of the Bureau of Entomology and Plant Quarantine are given in Table 5.

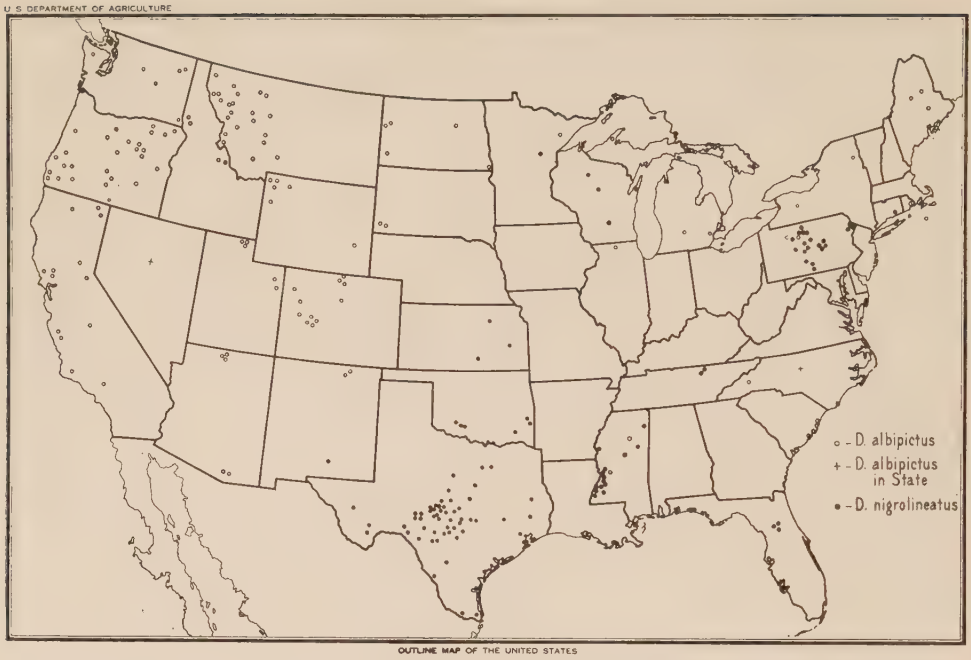

FIG. 5. Distribution of *Dermacentor albipictus* and *D. nigrolineatus* in the United States.

Dermacentor andersoni (Stiles)

Rocky Mountain Spotted Fever Tick

Dermacentor andersoni, known to many as *D. venustus* Banks, is of special interest because of its role in the transmission of Rocky Mountain spotted fever, Colorado tick fever, tularemia, and American Q fever, in the production of tick paralysis, and in the annoyance of man and other animals by its attack. Also Syverton and Berry (1936) have reported the experimental transmission of encephalomyelitis by it. The reputation of this tick as a disease carrier has an adverse influence on the development and utilization for recreation and other purposes of certain areas where it is abundant. Although this species has been intensively studied by members of the staff of the U. S. Public Health Service, the State Board of Ento-

TABLE 5.—Dermacentor albipictus: *Host records of the Bureau of Entomology and Plant Quarantine*

Host	Lots	Larvae	Nymphs	Males	Females
Antelope	2	....	1(2uf)	2(12)	2(10uf)
Caribou	1	....	....	1(1)	1(1u)
Cat*	1	....	1(3f)	1(3)	1(1u)
Cattle	11	....	5(23pf)	7(20)	9(+26uf)
Deer	14	1(1f)	9(+44pf)	8(+100)	12(198uf)
Deer, black-tailed (*Odocoileus hemionus*)	26	....	11(+38uf)	15(+27)	19(+78uf)
Deer, Virginia	2	....	1(2f)	2(9)	2(10sp)
Elk	23	....	6(15uf)	12(+63)	21(+214uf)
Elk, western wapiti	8	1(2u)	6(42uf)	5(17)	5(21sf)
Goat, mountain	1	....	1(2)	1(many)	1(many)
Horse	137	1(2s)	46(+391uf)	94(+515)	123(+912uf)
Man	1	....	....	1(1)	....
Moose	10	....	4(8pf)	8(+71)	8(+120uf)
Sheep, mountain	4	....	....	2(11)	3(10uf)

* Apparently all were partly to fully engorged nymphs when collected, and molting to adults took place after collection at Virginia Dale, Colo., Dec. 15, 1940.

mology of Montana, and the Bureau of Entomology and Plant Quarantine, there is still much to be learned regarding the interrelations of the parasite, its hosts, and the diseases it carries in different areas in which it occurs.

Distribution

The distribution of the Rocky Mountain spotted fever tick has been discussed and maps presented by a number of authors—Bishopp (1911b), Hooker, Bishopp and Wood (1912), Hunter and Bishopp (1911), and Cooley (1911, 1938). Information regarding its distribution in Canada has been referred to by numerous writers, particularly Hadwen (1923), and Twinn (1932, p. 164).

In general, this species ranges from the western counties of Nebraska and the Black Hills of South Dakota to the eastern slopes of the Cascades, and from the

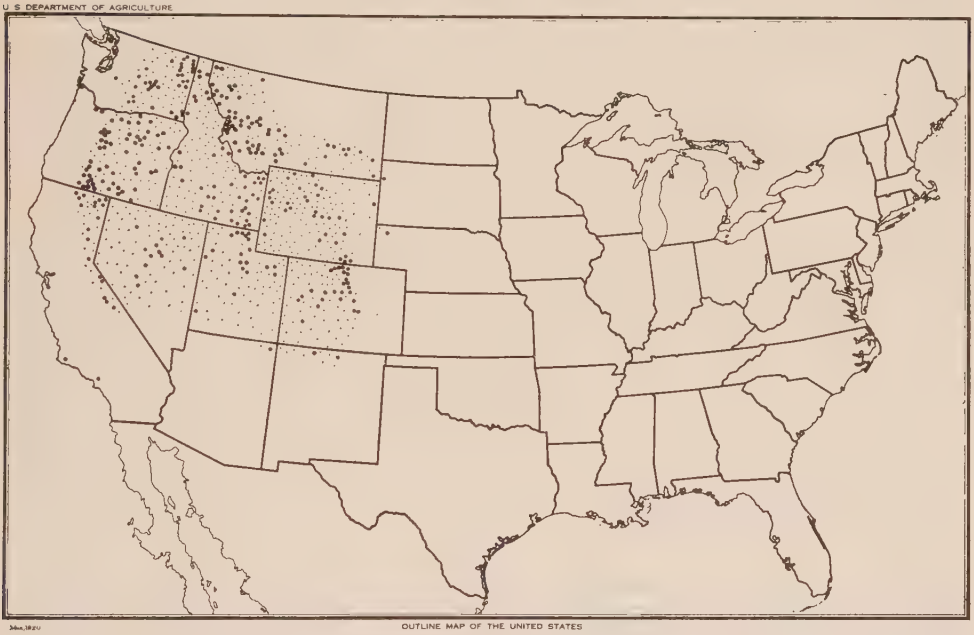

FIG. 6. Distribution of *Dermacentor andersoni* in the United States. Large dots indicate localities from which specimens are herein reported. Small dots indicate probable distribution of species.

northern portions of Arizona and New Mexico well into British Columbia and Manitoba (Fig. 6). As with most species of ticks, the abundance varies greatly in different areas, and there are included in the "area of probable distribution" on the map many districts of considerable size where usually the tick is a rarity. The species is especially abundant in rough, cut-over, mountainous areas, and in sagebrush country near streams, because such conditions provide favorable cover and abundant hosts for all stages of this tick.

Two records from western California (Santa Barbara and Whittier) are of interest in that they involve localities well outside the normal range of the species, and one of these (from Whittier) was of a one-third-engorged female from a patient in a hospital. This patient had not been away from that vicinity or out into areas likely to be infested. All these occurrences were of single specimens, undoubtedly

accidental introductions, and almost certainly do not represent established infestations. We have three records each from Bonneville, Ore., and Portland, Ore. The records from Bonneville indicate that the tick is present there in nature. Two of these lots (1 male and 2 males, respectively) were from Works Progress Administration workers, and the third lot consisted of 1 male and 1 female found attached to children. The collections from Portland do not indicate so strongly that the tick is normally present there. One of them (1 male and 1 female) was from children who had come from Pendleton, Ore., where the tick is abundant, and one was from a butcher who handled calves slaughtered and sold with the hides on. These animals may have originated in tick territory to the east.

This tick is abundant in southeastern British Columbia and throughout Alberta and Saskatchewan. Gibbons (1939) says, "There are also isolated records of its occurrence in Manitoba."

It is noteworthy that there is a definite overlapping of distribution of this species and *Dermacentor variabilis* in eastern California, eastern Montana, western North and South Dakota, and western Nebraska. It also appears that both species may be found in certain restricted areas in southern Oregon.

Hosts

Intensive studies of the host relations of *Dermacentor andersoni* have been made in the Bitter Root Valley of Montana and in the vicinity of Powder River, Mont.

Rather extensive collections also have been made in several of the infested states. This species does not attack birds or cold-blooded animals, but it is found on a great variety of mammals. The immature stages attach mainly to the smaller wild rodents that range in size from shrews and jumping mice to woodchucks and rabbits. They are found only rarely on the larger mammals and man. We have no records of the attachment of larvae to man, but have two clear-cut records of nymphs attached to children and adults.

The relative importance of different animals as hosts of the adults varies in different localities. It depends much on the abundance of the different host species. Horses and cattle are often very heavily infested, and, in general, may be regarded as the most important hosts of the adults.

The adults are found attached to animals soon after the snows begin to disappear, reach a maximum abundance during April and May, and decline in numbers about midsummer. Our earliest records are from northern Colorado. One male was collected on a calf January 6, 1918, at Virginia Dale by B. G. D. Bishopp. In the same locality a male was collected on February 15, 1916, and another on February 23, 1916, each on man. In Estes Park, Colo., a female was taken on clothing on February 22, 1925. Early adult activity was also observed at Viewpoint, Ore., where H. H. Hatch collected a male on man February 3, 1913, and specimens of both sexes on cattle on March 8, 1913.

The earliest record we have for the Bitter Root Valley is a male taken on clothing on March 11, 1910. Nymphs begin to appear on hosts early in April, but larvae do not appear to be found on hosts until the first half of June. Adults become scarce on hosts after August 1, but there are a number of records of the collection of occasional specimens in September and October. Most of the late records are from

Oregon, and the latest one was a male attached to man at Lake, Ore., November 22, 1920.

Records of the Bureau of Entomology and Plant Quarantine are given in Table 6.

TABLE 6.—Dermacentor andersoni: *Host records of the Bureau of Entomology and Plant Quarantine*

Host	Lots	Larvae	Nymphs	Males	Females
Antelope, American pronghorn	1	....	....	1(14)	1(2sp)
Ass	4	....	....	4(+8)	4(+6uf)
Badger	1	....	....	1(1)	....
Bear	1	....	....	1(4)	1(9sp)
Bobcat	1	....	....	1(1)	....
Cat, domestic	3	....	2(3)	1(1)	....
Cattle	95	....	?1(3)	73(+350)	81(+422)
Chipmunk, buff-bellied	11	7(173up)	6(10up)	....	....
Chipmunk, Colorado	1	1(2)	....	....	....
Chipmunk (*Eutamias* spp.)	15	8(432uf)	12(59uf)	....	....
Chipmunk, painted	1	....	1(1s)	....	....
Cony (including Taylor and Rocky Mountain pikas)	2	....	2(7uf)	1(1)	....
Coyote	1	....	....	1(15)	1(16up)
Coyote, Great Basin	1	....	....	1(1)	....
Deer, Rocky Mountain mule	4	....	....	3(7)	3(5uf)
Dog	21	....	....	14(+25)	16(+32uf)
Elk	2	....	....	2(2)	....
Goat	1	....	....	....	1(4us)
Goat, mountain	4	....	....	4(+8)	3(+5uf)
Ground squirrel (*Callispermophilus* spp.)	4	1(17sf)	4(7up)	....	....
Ground squirrel (chickaree), Douglas	3	1(13pf)	3(3uf)	....	....
Ground squirrel (*Citellus columbianus* subspp.)	64	19(514uf)	53(+801uf)	....	....
Ground squirrel (*Citellus* sp.)	3	1(13pf)	3(3uf)	....	....
Ground squirrel, gilded	2	1(5sp)	2(8sf)	....	....
Ground squirrel, little gray	1	....	1(2)	....	....
Ground squirrel, Montana mantled	16	6(67uf)	16(122pf)	....	....
Ground squirrel, Oregon	1	....	1(3s)	....	....
Ground squirrel, Wyoming	1	....	1(1s)	....	....
Hog	3	....	....	2(11)	2(10sp)
Horse	353	....	....	285(+2000)	332(+2574uf)
Man	270	....	2(2p)	189(+513)	204(614 up)
Mouse, Cary meadow	1	....	1(5sp)	....	....
Mouse (*Microtus* sp.)	2	....	2(9uf)	....	....
Mouse, Rocky Mountain jumping	1	1(1p)	....	....	....
Mouse, white-footed	4	1(4uf)	4(4us)	....	....
Mule	5	....	....	5(+9)	5(+13uf)
Pocket gopher, Nevada	2	2(sp)	....	....	....
Porcupine	13	....	....	13(+50)	12(57uf)
Porcupine, yellow-haired	3	....	....	3(31)	2(30uf)
Rabbit, Black Hills cottontail	2	1(3)	1(1)	1(1)	....
Rabbit, black-tailed jack	1	....	1(3nf)	....	....
Rabbit, cottontail	10	3(59uf)	9(28uf)	....	2(2pf)
Rabbit, cottontail (*S. nuttalli*)	1	....	1(1f)	....	....
Rabbit, Idaho pygmy	1	....	1(21uf)	....	....
Rabbit, jack	6	....	2(2)	4(19)	3(14up)
Rabbit, Rocky Mountain snowshoe	2	....	....	1(1)	1(1f)
Rabbit, snowshoe	3	....	1(1s)	1(1)	2(2pf)
Rabbit, Washington jack	7	....	1(2p)	3(10)	....
Rabbit, white-tailed jack	1	1(3)	....	....	....
Sheep	8	....	....	6(+37)	6(+32uf)
Squirrel, Richardson red	28	18(+644uf)	22(169uf)	....	....
Woodchuck (*Marmota flaviventer*)	25	1(8us)	26(194uf)	....	....
Woodchuck, pallid yellow-bellied	1	....	....	....	1(1u)
Woodchuck, yellow-bellied	2	....	2(16sf)	....	....
Wood rat, bushy-tailed	9	5(65uf)	6(13uf)	....	....
Wood rat, western bushy-tailed	1	1(12sf)	1(34sf)	....	....

Dermacentor nigrolineatus Pack.

The Brown Winter Tick

As explained in the discussion of *Dermacentor albipictus*, that species is regarded by some as identical with *D. nigrolineatus*. In this article these forms are considered as distinct. *D. nigrolineatus* remains on the host during each of its two molts. It is a cool-weather species, being found on hosts only during fall, winter, and spring.

This tick is a pest of considerable importance on horse and cattle in parts of the Southwest; and antelope, deer, and elk are sometimes heavily infested. It is not known to carry any disease, and we have no record of its attachment to man.

Distribution

This form is most abundant in the southern portions of the country, especially in the arid part of Texas and New Mexico (Fig. 5), and in northern Mexico. It is occasionally found also in considerable numbers on horses and cattle in the more humid parts of the South.

Hosts

The host relations of this species are similar to those of *Dermacentor albipictus*. In the Southwestern States it is very abundant on horses, which appear to be the preferred host. It is also commonly found on mules, cattle, deer, and antelope.

Adults begin to appear on hosts about October 1. For instance, we have records from Akin County, Minn., September 28, 1937, and Summerville, S. C.,

TABLE 7.—Dermacentor nigrolineatus, D. nitens, D. occidentalis, *and* D. parumapertus: *Host records of the Bureau of Entomology and Plant Quarantine*

Host	Lots	Larvae	Nymphs	Males	Females
	Dermacentor nigrolineatus				
Antelope	5	.....	2(4sf)	2(23)	5(122uf)
Ass	1*	.....	.....	.....	.....
Bison, American	3	.....	2(2pf)	1(5)	1(8p)
Cattle	48	1(+)	17(+170uf)	16(91)	42(+265uf)
Deer, mule (including some skins)	3	.....	.....	1(3)	3(6us)
Deer, Virginia	74	5(13pf)	34(+640uf)	52(+283)	50(+295uf)
Mule	3	.....	.....	1(1)	3(8pf)
	Dermacentor nitens				
Cattle	5	.....	1(3pf)	3(+4)	2(+1f)
Deer, Virginia	..	.....	†	†	†
Goat	1	.....	1(1p)	†	†
Horse	20	3(†uf)	(‡ uf)	13(+84)	10(‡ uf)
Mule	7	.....	3(†)	6(†)	4(† uf)
	Dermacentor occidentalis				
Ass	1	.....	.....	‡ uf	‡ uf
Cattle	42	.....	.....	32(+179)	37(+235uf)
Chipmunk, Merriam	1	1(2s)	1(6sf)	.....	.....
Deer, Rocky Mountain mule	11	.....	.....	12(17)	7(11up)
Dog	3	.....	.....	2(3)	3(4u)
Ground squirrel	1	.....	.....	1(1)	.....
Horse	41	.....	.....	27(106)	39(+115uf)
Man	44	.....	.....	29(59)	32(81us)
Mouse, Gambel white-footed	2	.....	1(1p)	.....	.....
Mule	10	.....	.....	5(8)	7(16uf)
Rabbit	1	.....	1(2s)	1(13)	1(12up)
Sheep	1	.....	.....	1(1)	.....
Wood rat, large-eared	1	.....	1(2sp)	.....	.....
Wood rat, Streator	1	1(1)	.....	.....	.....
	Dermacentor parumapertus				
Cattle	1	.....	.....	.....	1(6sf)
Mouse, pocket	1	1(50up)	.....	.....	.....
Mouse, Tejon pocket	4	2(74sf)	4(7sf)	.....	.....
Rabbit	22	.....	5(7uf)	20(136)	20(98uf)
Rabbit, antelope jack	6	1(5f)	.....	5(+26)	5(+29uf)
Rabbit, California jack	6	.....	3(42uf)	4(12)	5(17uf)
Rabbit, Colorado desert jack	1	1(20sp)	1(7uf)	.....	.....
Rabbit, cottontail	18	5(27uf)	8(32uf)	5(+19)	7(+17uf)
Rabbit, Great Plains jack	2	2(26up)	1(2f)	1(1)	.....
Rabbit, jack	93	6(65sp)	24(259uf)	56(571)	66(421uf)
Rabbit, pygmy	1	.....	.....	1(1)	1(1s)
Rabbit, white-tailed jack	1	.....	.....	1(2)	.....
Rat, Mohave kangaroo	1	.....	1(3sf)	.....	.....
Rat, Richardson kangaroo	1	1(17us)	.....	.....	.....

* All stages. † Several. ‡ Many.

October 1, 1933. Seldom are they present on hosts after the middle of April (Warren County, Miss., April 15, 1921, and Alamogordo, N. Mex., April 12, 1923 are records of late occurrence). They have been collected on animals throughout the winter. Bureau records are shown in Table 7.

Dermacentor nitens Neum.

The Tropical Horse Tick

The tropical horse tick is a pest of distinct importance in extreme southern Texas and southward through the warmer parts of Mexico, Central America, and in the West Indies. It remains on the host for each of its two molts and is most commonly found in the ears of horses, asses, and mules. Although its mouthparts

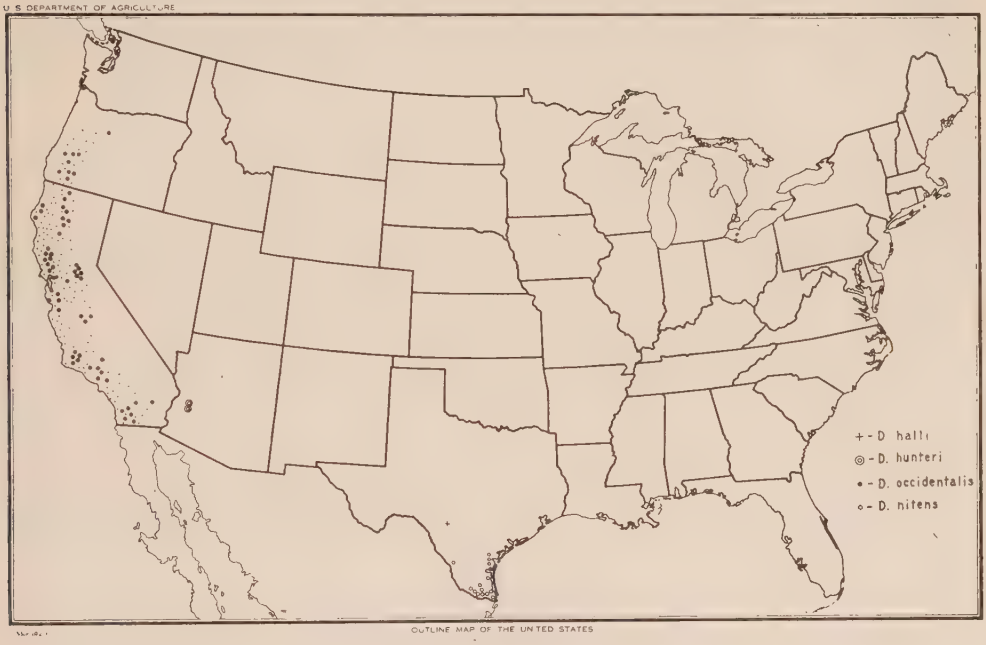

FIG. 7. Distribution of *Dermacentor halli, D. hunteri, D. occidentalis,* and *D. nitens* in the United States.

are short it frequently sets up considerable inflammation, and screwworm infestations may follow. The inside of the ears of hosts frequently becomes closely packed with ticks in all stages and with molted skins and tick excrement which produces a nauseating odor. Infested animals are sensitive when the ears are touched, and putting on halters and bridles becomes difficult.

Distribution

The types of the species came from Jamaica and Santo Domingo. The tick is abundant in the southern part of Texas and along the east coast of Mexico. It is also abundant in the West Indies. The Bureau collections contain specimens from Jamaica, Puerto Rico, Cuba, Dominica, Haiti, Saint Thomas, and Saint Croix, also from Guatemala, Costa Rica, Honduras, Panama, and the Canal Zone in Central America. The species has also been recorded from Trinidad and Colombia.

The distribution in the United States is indicated on the accompanying map (Fig. 7). The published record (Banks, 1908) of the occurrence of the species in Arizona is probably based on specimens introduced on horses shipped into that State. Corpus Christi, Nueces County, Tex., is the northernmost locality in which it occurs commonly. Although a single nymph was collected at Kerrville, Tex., on a deer skin and reported by Hooker, Bishopp, and Wood (1912) as apparently of this species, subsequent extensive collecting in that area has failed to reveal its presence. In addition to this collection in Kerr County, the Bureau collection contains specimens from the following Texas counties: Cameron, Hidalgo, Nueces, San Patricio, Webb, and Willacy.

The fact that this tick remains on a host for its molts and requires 26 days, or longer, for its development on a host gives ready opportunity for it to be shipped long distances. There is no evidence, however, that it has become established in any of the more northern localities in this country to which infested animals have undoubtedly been shipped.

Hosts

Horses, asses, and mules are preferred hosts of the tropical horse tick. A high percentage of these hosts in the Brownsville, Tex., area and along the east coast of Mexico are infested. Tate (1941, p. 19) found 57 per cent of 131 horses examined in various parts of Puerto Rico to be infested and about 15 per cent of the goats and sheep.

The inside of the external ear is the preferred place of attachment, but it is not very unusual to find this species on the outside of the ears, on the top of the head, in the mane, or occasionally on the body.

This tick in all stages is found on hosts throughout the year, though it is probably more abundant in Texas during the fall, winter and spring.

Bureau collection records in the United States are given in Table 7.

The collection also contains many lots from the West Indies, Mexico, and Central America from ass, goat, horse, mule, and sheep.

Dermacentor occidentalis Marx

The Pacific Coast Tick

The Pacific Coast Tick is a common wood tick in western California and southwestern Oregon. Although it frequently attaches to man, it has not been definitely shown to transmit Rocky Mountain spotted fever in nature, although Parker, Philip, and Jellison (1933) found it to be a transmitter of the fever under experimental conditions; and there appears to be no reason why it should not serve as a vector among both wild rodents and man. Parker, Brooks, and Marsh (1929) demonstrated the occurrence of tularemia organisms in adult ticks received from cattle in California, and *Bacterium tularense* has been found repeatedly in adults of this species in nature. Anaplasmosis of cattle has been transmitted by larvae and nymphs in experiments by Herms and Howell (1935).

Distribution

The type locality of the Pacific Coast tick is Occidental, Calif. The tick is rather abundant in the Coastal Ranges and Cascade Range in California and southern

Oregon, and less abundant in the San Joaquin and Sacramento Valleys and on the west side of the Sierra Nevada (Fig. 7). Reports of the occurrence of this tick in Texas, New Mexico, and Arizona are probably incorrect; at any rate it does not appear to be established in any of those States. Since this species is present in abundance in southern California, it undoubtedly occurs in Lower California. Our northernmost record is from Ashwood, Ore. (2 nymphs, 13 males, 12 females from rabbit, June 16, 1910). Chamberlain (1937) reported a collection nearly as far north but on the west side of the Cascades at Yachats, Lincoln County, Ore.

Hosts

Deer was the host of the type specimen. This animal is an important host of the adults, which sometimes are present on it by the hundreds. Cattle and horses are important hosts of the adults, and in a few instances nymphs have been taken on these animals. Larvae and nymphs engorge readily on bovines—also on rabbits and guinea pigs according to Hooker, Bishopp, and Wood (1912).

Kohls (1937) made a study of the host relations of the immature stages of the Pacific Coast tick in Oregon and California and listed 26 hosts. He concludes that, because of their abundance and general distribution in regions infested by this species, ground squirrels (*Citellus douglasii* and *C. beecheyi*) and white-footed mice (*Peromyscus* spp.) are of major importance. He also concludes that the following are important: Wood rats (*Neotoma* spp.), bush rabbits (*Sylvilagus bachmani*), cottontail rabbits (*S. audubonii*), jack rabbits (*Lepus californicus*), pocket mouse (*Perognathus* sp.), and chipmunk (*Eutamias* sp.). He reports that a single nymph was found attached to his arm. Chamberlain (1937) lists lizard as a host in Oregon.

The immature stages appear to be most abundant on hosts in the spring and summer. Our collection contains adults taken every month except September, thus indicating its presence on hosts throughout the year. Adults reach a peak of abundance in April and May. The Bureau host records are shown in Table 7.

Dermacentor parumapertus Neum.

The Rabbit Dermacentor

The authors consider the form *Dermacentor parumapertus marginatus* Banks as indistinguishable as an entity from *D. parumapertus*.

This species has not been shown to be of any particular economic importance, as it confines its attack largely to rabbits. It may well play a part, however, in transmitting tularemia, Rocky Mountain spotted fever, and other diseases among these animals.

The types were recorded from "man and in a chicken house," Lakeside, Calif. Banks' types of *Dermacentor parumapertus marginatus* were from jack rabbit, Mesa, Ariz.

Distribution

The rabbit *Dermacentor* is fairly abundant in the Southwestern States west of the 100th meridian and in the arid portions of northern Mexico. It appears to thrive in areas of light rainfall and is found in association with rabbits under extreme desert conditions. Although it has been collected in timbered sections of the

West, it is more typically a desert species. It is most abundant in western Texas and southern New Mexico, Arizona, and California. It is fairly abundant in some parts of Utah and Nevada (Fig. 8).

The seasonal occurrence of this tick is interesting but not well understood. The immature stages are found on hosts mainly during the cooler months, September to May. The adults are present on hosts throughout the year in the southern range of the species although they are more abundant in summer. Often large numbers of females are found with few or none showing appreciable engorgement; again, considerable numbers of engorging females are in evidence. This has suggested a possible relation between engorgement and seasonal rainfall.

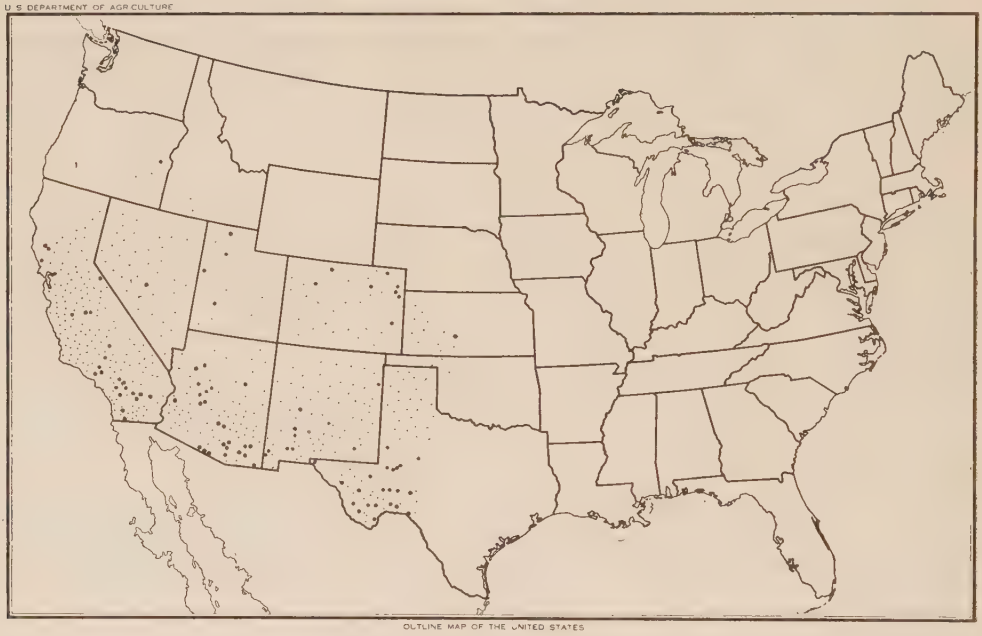

FIG. 8. Distribution of *Dermacentor parumapertus* in the United States. Large dots indicate localities from which specimens are herein reported. Small dots indicate probable distribution of species.

Hosts

Jack rabbits are the principal hosts of the larvae, nymphs, and adults, partly because of the greater abundance of these rabbits in much of the region inhabited by the tick. Other kinds of rabbits are excellent hosts, however, and some are found to be heavily infested. Our records show no collections on man or domestic animals except one lot from cattle collected by R. W. Wells at Wilcox, Ariz., July 29, 1918. Experimentally, adults of this species feed readily on cattle. Boynton and Woods (1933) have recorded this species from deer, and Cooley (1938) has seen specimens taken from coyote in California.

Bureau records of hosts are given in Table 7.

Dermacentor variabilis (Say)

The American Dog Tick

The American dog tick is the principal transmitter to man of Rocky Mountain

spotted fever in the Mississippi Valley, eastward to the Atlantic and southward to the Gulf of Mexico, and including Texas. It plays a small part in the transmission of tularemia and is a source of much annoyance to man and dogs. The experimental transmission of anaplasmosis has been reported by Rees (1934). Dogs are often so heavily infested as to become emaciated, cross, and unsightly. Some districts along the Atlantic Coast have been so adversely affected by the abundance of this tick as to impair their popularity as summer recreational areas.

Distribution

The American dog tick is one of our most widely distributed ticks, but its abundance varies greatly in different localities. As shown on the accompanying map (Fig. 9) it is found throughout the United States with the exception of Washington

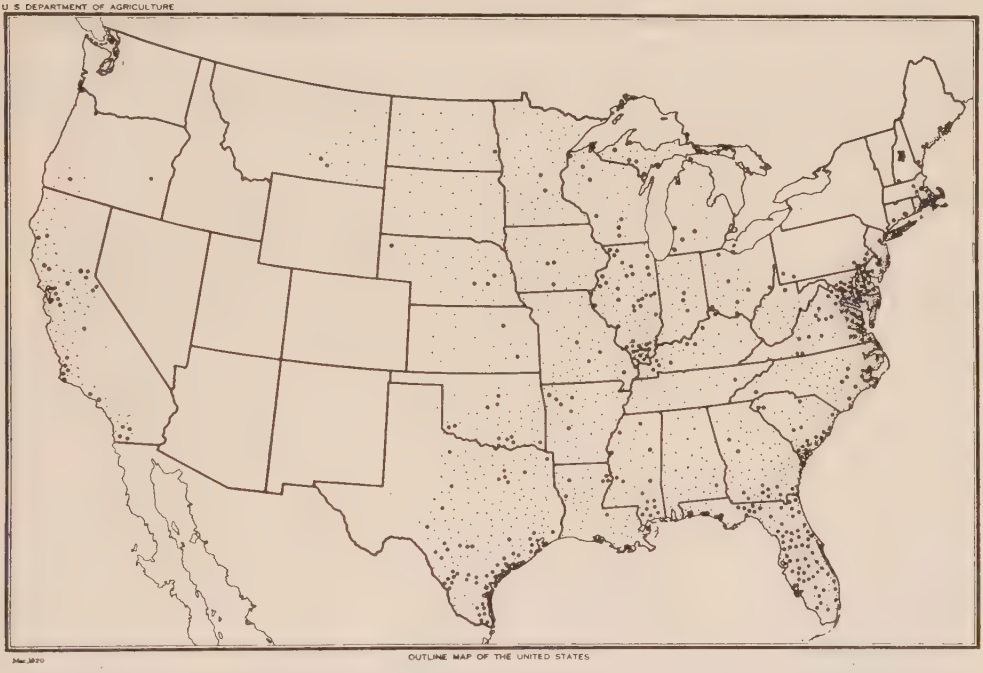

FIG. 9. Distribution of *Dermacentor variabilis* in the United States. Large dots indicate localities from which specimens are herein reported. Small dots indicate probable distribution of species.

and the Rocky Mountain and Intermountain regions. This species is commonly met in the southern provinces of Candada, and is found in Mexico. It has been reported from Alaska, and there is one record of its occurrence in each of the States of Colorado, Arizona, and New Mexico, but it is doubtful if the occurrence is normal in these localities.

This tick appears to be favored by a humid atmosphere, and this probably is a factor in governing its distribution and abundance. It is very numerous on islands along the east coast of the United States, on Cape Cod, Long Island, and southward along the coast. It is common also in the Gulf Coast States, especially Florida and Texas. As pointed out by Bishopp and Smith (1938), it is less abundant on the north side than on the south side of Cape Cod, and there are few north of Plymouth,

Mass., or inland beyond Middleboro and Taunton, Mass. Since this species is dependent on small, wild rodents as hosts for the immature stages, the distribution and abundance of these animals is an influencing factor on the incidence of the tick, but this does not account for the absence of the species inland in Massachusetts and in many other areas. High humidity appears to be an important factor favoring this species. Heavily-forested areas have fewer ticks than grassy and brush-covered ones, probably on account of the relative scarcity of small animal hosts and appropriate ground cover.

Hosts

The adults prefer the dog as a host, and although man is frequently attacked, he is not among the preferred group. The immature stages engorge mainly on small rodents, especially mice; of these, meadow mice are preferred, perhaps on account of their habits. In the Southern States ticks in all stages may be found on hosts throughout the year, though they are usually more abundant in the spring. The tendency for the adults to attach to hosts in the spring is more pronounced in the Central and Northern States. In fact, in the North they are uncommon on hosts

TABLE 8.—Dermacentor variabilis: *Host records of the Bureau of Entomology and Plant Quarantine*

Host	Lots	Larvae	Nymphs	Males	Females
Ass	1	.....	.....	1	1(f)
Badger	6	.....	.....	4	6(6uf)
Bear	1	.....	.....	*	*
Cat, domestic	5	.....	2(p)	1	2(f)
Cattle	35	.....	1(f)	18	25(uf)
Coyote	26	.....	.....	16	19(pf)
Deer	3	.....	.....	2	2(uf)
Dog	277	.....	3(pf)	147	218(uf)
Fox	3	.....	.....	2	1(f)
Goat	1	.....	.....	1	.....
Gopher, southern pocket	1	1(u)	.....	.....	.....
Hog	20	.....	.....	8	17(uf)
Horse	20	.....	.....	10	14(uf)
Leopard-cat	1	.....	.....	.....	1(f)
Man	113	.....	.....	48	70(up)
Mexican lion	1	.....	.....	.....	1(u)
Mole	1	1(u)	.....	.....	.....
Mountain lion	1	.....	.....	1	1(f)
Mouse	10	6(uf)	6(uf)	.....	.....
Mouse, Baird's	1	1(u)	.....	.....	.....
Mouse, Cooper's	1	1(f)	.....	.....	.....
Mouse, house	3	3(u)	.....	.....	.....
Mouse (including white-footed and cotton)	79	80(uf)	25(uf)	.....	.....
Mouse, jumping	2	1(f)	1(u)	.....	.....
Mouse, meadow	20	18(uf)	19(uf)	.....	.....
Mouse, pine	11	4(up)	8(uf)	.....	.....
Mule	1	.....	.....	.....	1(u)
Muskrat	3	2(38pf)	2(2pf)	1(10)	1(6pf)
Opossum	20	.....	1(1)	18	15(uf)
Peccary	3	.....	.....	2	2(f)
Porcupine	2	.....	1(1p)	1(2)	1(s)
Rabbit, black-tailed jack	1	1(3s)	.....	.....	.....
Rabbit, cottontail	34	27(uf)	14(uf)	2	1(s)
Rabbit, domestic	1	.....	.....	1(2)	1(s)
Rabbit, Florida marsh	2	1(p)	2(p)	.....	.....
Raccoon	13	.....	.....	11	9(uf)
Rat, cotton	13	10(52uf)	9(27sf)	.....	.....
Rat, Norway	5	4(up)	1(p)	.....	.....
Rat (*Rattus* sp.)	1	1(1u)	1(1f)	.....	.....
Rat, rice	15	13(+66uf)	8(+25sf)	.....	.....
Sheep	7	.....	.....	5	5(uf)
Shrew, short-tailed	2	2	1	.....	.....
Skunk	5	.....	.....	5	3(us)
Squirrel (including fox, gray and red)	19	1(f)	7	8	8(sp)
Weasel	3	.....	.....	1	2
Wildcat (lynx)	10	.....	.....	8	8(uf)
Wolf	4	.....	.....	4	3
Woodchuck	3	.....	.....	5	6(sp)
Wood rat (*Neotoma* sp.)	1	.....	1(p)	.....	.....

* Several.

after August 1 although stragglers may be found up to the occurrence of freezing weather. The adults first appear in the spring on hosts in Maryland between March 15 and April 15, and the height of abundance comes in the latter part of May or early in June. Larvae and nymphs are found on meadow mice throughout the winter in the vicinity of the District of Columbia. Farther north, in New Jersey and Massachusetts, this is not true. Here the immature stages occur on hosts throughout the spring, summer, and fall, but the larvae are much less abundant in the spring. The relative frequency with which this tick, in its different stages, is taken on various hosts is indicated by the collection records of the Bureau of Entomology and Plant Quarantine in Table 8.

Dermacentor hunteri Bishopp

Distribution

Dermacentor hunteri appears to have a very limited distribution. It has been taken by us only among the isolated mountain peaks of southwestern Arizona (Fig. 7).

Hosts

Mountain sheep (originally referred to as *Ovis mexicanus* but later identified as *O. canadensis gaillardi* Mearns) is the type host and we have no collections from other hosts. The type of the species was chosen from a lot of 23 males and 12 females collected at Quartzside, Ariz., on September 2, 1911, by Mr. George Hutson. Several other lots of males and females (in various stages of engorgement) were collected during July, August, September, November, and December in the same locality and at altitudes of 1,500 to 2,000 feet.

Haemaphysalis chordeilis Pack.

The Bird Tick

The bird tick appears to have a rather wide distribution in the United States, but only occasionally does it assume economic importance. Losses caused by it have been observed among turkeys and certain game birds. It may sometimes have an adverse effect on other wild birds, also. There is some confusion in the taxonomy of this species. Nuttall et al. (1915) regard *Haemaphysalis chordeilis* Pack. as a synonym of *H. cinnabarina* Koch. We are inclined to think these forms distinct, and the records presented herein are based on the restricted application of the name.

Distribution

This is an American species which is found in the eastern and southern parts of the United States and in eastern Canada. If the broader interpretation of the species as mentioned above is applied, the western states and western Canada would also be included. Our records seem to indicate that it is most abundant in the Gulf Coast and Atlantic Coast regions (Fig. 10). Bureau records do not indicate its presence in the Rocky Mountain and intermountain regions. Dr. W. A. Riley informs us that he received a report of a severe infestation of what he then called *H. cinnabarina* on turkeys in northern Minnesota. Apparently the species does not thrive in the drier portions of the country. No doubt the immature stages and perhaps the adults have been collected in many instances and considered as *Haema-*

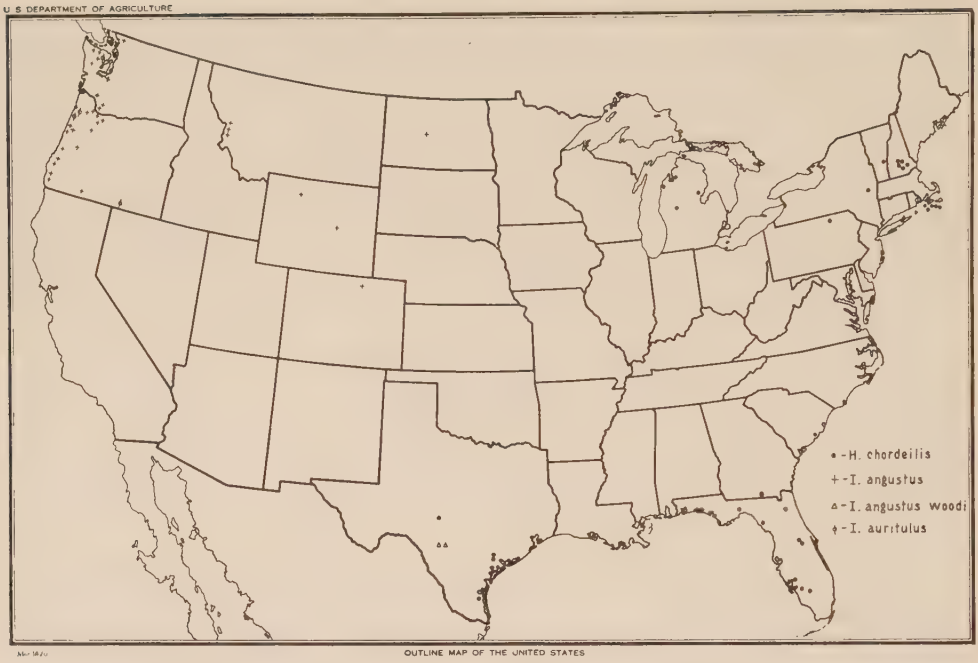

FIG. 10. Distribution of *Haemaphysalis chordeilis, Ixodes angustus, I. a woodi,* and *I. auritulus* in the United States, as indicated by collections of the Bureau of Entomology and Plant Quarantine.

physalis leporis-palustris, and more intensive collecting will show the species to be more widely distributed than shown in Fig. 10.

Hosts

Birds are the preferred hosts of all stages of this species, hence the common name "bird tick." Grouse and meadowlarks appear to be most freely attacked. The infestation of turkeys by this tick has been recorded by Banks (1908). The writers have obtained information to the effect that the bird tick often causes the death of poults along the coast in Connecticut, and that young grouse reared and

TABLE 9.—Haemaphysalis chordeilis: *Host records of the Bureau of Entomology and Plant Quarantine*

Host	Lots	Larvae	Nymphs	Males	Females
Blackbird, red-winged	1	.....	1(2f)	.....	.....
Cow	1	.....	.....	.....	1(1p)
Grouse, ruffed (including *Bonasa umbellus*)	16	7(31sf)	10(24sf)	4(26)	10(18sp)
Hawk, marsh	1	.....	1(2)	.....	.....
Horse	1	.....	.....	.....	1(1p)
Jackdaw	5	5(39uf)	.....	.....	.....
Man	1	.....	.....	.....	1(1)
Meadowlark	24	12(+110uf)	16(147uf)	9(26)	2(5p)
Meadowlark, southern	21	10(+194 uf)	13(+48sf)	6(21)	4(9sp)
Quail	4	1(15uf)	2(21uf)	.....	1(9uf)
Sheep	1	.....	.....	.....	1(1u)
Sparrow, Florida	1	1(1f)	1(2f)	.....	.....
Sparrow, Savannah	2	.....	2(2sp)	.....	.....
Sparrow, Wakulla seaside	1	.....	1(1u)	.....	.....
Towhee	1	1(1f)	.....	.....	.....
Turkey	2	1(+1f)	.....	.....	2(+2pf)
Wren, Florida	1	1(1s)	.....	.....	.....

released in late summer on Fishers Island, N. Y., often become heavily infested, and that the mortality is rather high. That there is some tendency for this species to catch hold of clothing is indicated by the fact that C. N. Smith collected 16 males and 17 females on clothing and on a cloth drag at Woods Hole, Mass., April 23, 1941.

All specimens of the bird tick collected in the South (Florida, Georgia, and Texas) were taken during late fall, winter, and early spring and those in the North were collected during the spring, summer, and fall.

Other Bureau of Entomology and Plant Quarantine records are to be found in Table 9.

Haemaphysalis leporis-palustris Pack.

The Rabbit Tick

The rabbit tick is one of the most common and widely distributed species of ticks in North America. The fact that it does not ordinarily attack domestic animals and that it never attacks man cause it to be ranked as of little economic importance. However, since it becomes so abundant on wild rabbits and certain birds as to weaken if not kill them, and since it is capable of carrying tularemia and Rocky Mountain spotted fever from animal to animal, it should be placed among the species of importance to man.

Hooker, Bishopp, and Wood (1912, p. 96) record the collection of 1,033 specimens of this tick, many of which were engorged females, on 2 snowshoe hares. Greene, Bell, and Evans (1938) have reported infestations of this hare reaching an average of almost 5,000 ticks per animal in September and October 1933, and in excess of 4,000 per animal during the late summer of 1935. The authors have observed quail and meadowlarks so heavily infested that they were emaciated and they believe that some, especially the young birds, may be killed by gross infestation. This tick occasionally attaches to chickens. The authors have one record of 19 larvae picked from the head and throat of a chick in 24 hours at Harvel, Ill., September 5, 1922.

Distribution

The rabbit tick is widely distributed in North America, from Alaska and the Southern Canadian Provinces southward well into Mexico. Collections of the Bureau of Entomology and Plant Quarantine contain specimens from every State in the Union except South Dakota, Nebraska, Missouri, Arkansas, Delaware, Kentucky, and West Virginia, and there is no reason to believe that it does not occur in those 7 States. It appears to be least abundant, in proportion to the number of rabbits, in extreme western Texas, in New Mexico, in Arizona, and in northern New England. Although the accompanying map (Fig. 11) indicates that many lots were collected in Texas, this does not mean that the tick is more abundant there than in many other parts of the country.

Hosts

Rabbits are the preferred hosts of this tick, particularly of the adult stage; in fact, it is unusual to find adults on any other host. Birds of many kinds serve as hosts of the larvae and nymphs, and, as indicated above, certain ground-inhabiting birds may be very heavily infested. In general, these ticks attach in greatest numbers

to the heads of their hosts. A large percentage of those on birds are to be found on the top and back of the head, and around the eyes and ears. In the case of rabbits, a large percentage of the ticks attach to the ears, around the eyes, and on other parts of the head; occasionally they are found between the toes and on the body.

The rabbit tick in all stages is found attached to hosts throughout the year in the Southern States. Its activity ceases during the colder parts of the year in the more northern States. Green, Bell, and Evans (1938) found 9 ticks on 13 hares during the first week in December 1931; they found none during the second week on 16 hares, but found that immature ticks began to attach to hares in small numbers during the first half of May in 1938. Philip (1938) found the rabbit tick in moderate numbers on the various hares near Seward and Fairbanks, Alaska, during

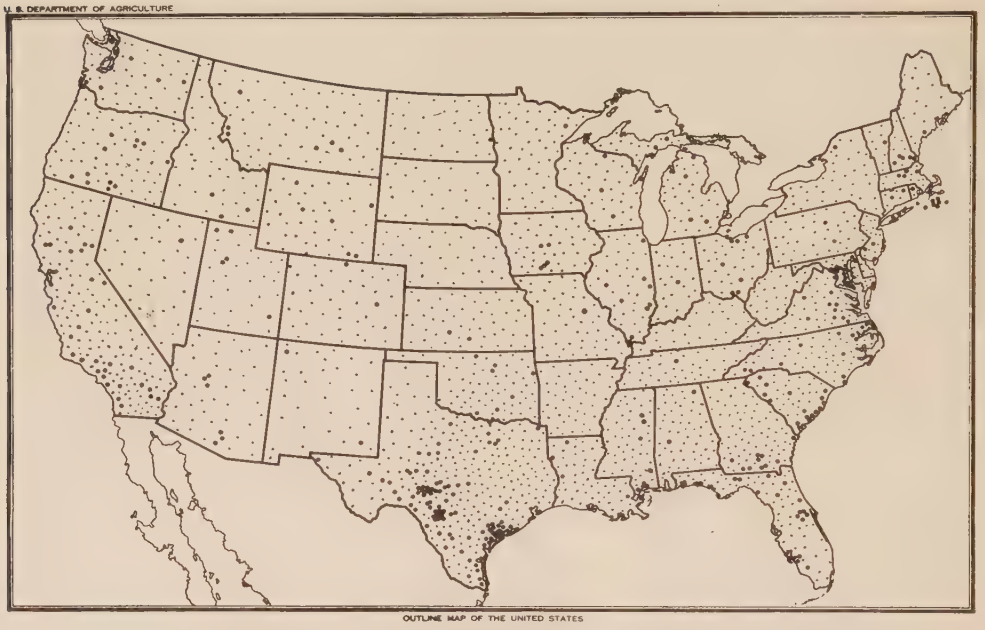

FIG. 11. Distribution of *Haemaphysalis leporis-palustris* in the United States.

June and July. This species is generally more abundant on hosts in spring and fall in the southern portions of the country. It appears to be more or less active during the winter along the Atlantic Coast even as far north as Marthas Vineyard, Mass., as C. N. Smith and M. M. Cole collected 1 nymph and 3 females on a cottontail rabbit on January 29, 1940, and 1 larva and 3 females in January 31, 1941. Nymphs and adults were also taken there in the latter part of March 1941. Collections made by E. B. Marshall in the vicinity of Laurel, Md., during several years show that large numbers of larvae in all states of engorgement and a few nymphs were present on quail through October and November. Joyce and Eddy (1943) examined 56 cottontail rabbits in Iowa between April 16 and December 23, 1941, and found the maximum number per animal (all stages) to occur in August. Adults were most abundant there in spring and absent in October to December, and larvae reached a peak of abundance in August and nymphs in October. The Bureau of Entomology and Plant Quarantine has records of hosts as shown in Table 10.

TABLE 10.—Haemaphysalis leporis-palustris: *Host records of the Bureau of Entomology and Plant Quarantine*

Host	Lots	Larvae	Nymphs	Males	Females
Blackbird, Brewer's	2	3	2	.....	.....
Blackbird, red-winged	7	3(25sp)	3(4up)	.....	.....
Bluebird	1	1(2p)	.....	.....	.....
Bluejay	10	10(31uf)	4(8sp)	.....	.....
Bunting, painted	1	1(3s)	.....	.....	.....
Cardinal	23	11(47sf)	15(46uf)	.....	.....
Cat	1	1(+p)	.....	.....	.....
Catbird	3	1(+s)	1(+u)	.....	1(+sp)
Chaparral cock	15	11(+uf)	12(+sf)	.....	.....
Chat, yellow-breasted	1	1(+p)	.....	.....	.....
Chicken, domestic	5	4(+sf)	2(+sf)	.....	.....
Cowbird	4	4(+uf)	3(+sf)	.....	.....
Crow	2	1(+f)	1(f)	.....	.....
Dove, mourning	1	.....	1(s)	.....	.....
Fox (faeces)	1	.....	1(s)	.....	.....
Goat	2	1(2p)	1(6sp)	.....	.....
Goldfinch	2	.....	1(1)	.....	.....
Grackle bronze	3	2(s)	1(f)	.....	.....
Grackle, purple	2	1(2up)	1(1)	.....	.....
Ground squirrel	1	.....	.....	.....	1(1p)
Ground squirrel striped	1	.....	.....	1(2)	.....
Grouse, ruffed	31	21(many sf)	30 (many uf)	.....	.....
Grouse, sharp-tailed	1*	.....	.....	.....	.....
Junco	8	5(27sf)	6(7sf)	.....	.....
Kinglet, ruby-crowned	1	1(1u)	.....	.....	.....
Lark, horned	1	1(1f)	1(10sf)	.....	.....
Lark, prairie horned	1	1(2s)	.....	.....	.....
Magpie	2	2(18p)	1(1p)	.....	.....
Meadowlark, eastern	24	20(243uf)	15(42uf)	.....	.....
Meadowlark, western	17	4(28sf)	15(111uf)	.....	.....
Mockingbird	2	2(2pf)	.....	.....	.....
Mouse, cotton	1	1(p)	.....	.....	.....
Mouse, northern golden	2	1(2p)	.....	.....	.....
Mouse, northern golden nest	1	.....	.....	.....	1(1u)
Mouse, parasitic	1	.....	1(1p)	.....	.....
Oven-bird	3	3(7)	1(1)	.....	.....
Owl, buffy prairie	1	1(4sf)	1(4sf)	.....	.....
Prairie chicken	3	2(18up)	.....	1(+2)	.....
Quail (bobwhite, mostly)	81	54(uf)	54(uf)	1(+)	3(4up)
Quail, California desert	1	1(20up)	1(4p)	.....	.....
Quail, California valley	2	2(100sp)	1(2u)	.....	.....
Quail, Mexican scaled	4	4(96up)	3(10up)	.....	.....
Rabbit, cottontail	426	173(+uf)	252(+uf)	189	213(+uf)
Rabbit, domestic	3	1(1u)	1(1s)	2	2(sf)
Rabbit, eastern cottontail	23	1(1s)	13(66sf)	13(47)	16(38sf)
Rabbit, jack (including Washington and Colorado desert)	123	13(93+uf)	48(427+uf)	90(746+)	86(501+uf)
Rabbit, Oklahoma cottontail	5	3(32sp)	2(17sp)	1(1)	2(6up)
Rail, sora	1	1(14uf)	1(2p)	.....	.....
Rat, roof	1	1(1s)	.....	.....	.....
Redstart	1	1(1)	.....	.....	.....
Robin	9†	4(+us)	7(+2uf)	.....	.....
Sparrow, Bachman's	2	.....	2(2uf)	.....	.....
Sparrow, chipping	4	1(1s)	3(4up)	.....	.....
Sparrow, English	1	1(17uf)	.....	.....	.....
Sparrow, field	3	2(2us)	2(2u)	.....	.....
Sparrow, fox	2	.....	2(2s)	.....	.....
Sparrow, Gambel's	1	.....	1(9pf)	.....	.....
Sparrow, Lincoln	1	.....	1(1p)	.....	.....
Sparrow, Savannah	10	2(5pf)	2(7up)	.....	.....
Sparrow, song	33	24(+uf)	21(+uf)	1	.....
Sparrow, swamp	9	5(25uf)	8(uf)	.....	.....
Sparrow, tree	1	1(1p)	.....	.....	.....
Sparrow, vesper	1	.....	1(3pf)	.....	.....
Sparrow, western field	1	1(4s)	.....	.....	.....
Sparrow, white-crowned	5	4(9pf)	2(11sf)	.....	.....
Sparrow, white-throated	16	11(uf)	11(uf)	.....	.....
Squirrel, fox	2	.....	1(2f)	.....	1(2p)
Squirrel, gray	1	1(1s)	.....	.....	.....
Squirrel, pine	1	1(21p)	.....	.....	.....
Starling	5	5(27sf)	.....	.....	.....
Thrasher, brown	17	11(uf)	15(uf)	.....	.....
Thrasher, Crissal	1	.....	1(1s)	.....	.....
Thrasher, sage	1	1(1p)	.....	.....	.....
Thrush, hermit	9	9(+uf)	2(2s)	.....	.....
Thrush, olive-backed	6	6(uf)	4(4up)	.....	.....
Thrush, wood	1	.....	.....	.....	1(1s)
Titmouse	2	2(51uf)	2(8sf)	.....	.....
Titmouse tufted	2	2(4up)	.....	.....	.....
Towhee	1	11(+36up)	5(26uf)	.....	.....
Towhee, Alabama	1	1(2u)	.....	.....	.....
Towhee, arctic	1	1(10sp)	.....	.....	.....
Towhee, canyon	1	.....	1(1f)	.....	.....
Towhee, red-eyed	3	2(3f)	1(9sf)	.....	.....
Towhee, white-eyed	3	3(14sf)	2(9sp)	.....	.....
Wood rat, Florida	1	1(1)	.....	.....	.....

* Several ticks.
† Adult 1.

Ixodes angustus Neum.

Ixodes angustus has been considered as of no economic importance. However, the fact that it is a general feeder and occasionally attacks man, coupled with the fact that it occurs in areas where Rocky Mountain spotted fever is prevalent, should cause it to be regarded with some suspicion. It does not appear to be abundant in any locality.

Distribution

The type female was collected at Shoshone, Idaho. This tick is found most commonly in western Oregon and Washington. Its distribution extends southward into California (Walker Pass and Siskiyou County, Banks, 1908) and northward into British Columbia. Hearle (1938) states that it is one of the commonest species in British Columbia, especially in the coastal district. It has also been recorded from Glacier Bay, Alaska (Banks, 1908). As indicated on the map (Fig. 10), in addition to numerous collections in western Washington and Oregon we have a few specimens from Colorado, Wyoming, Montana, and North Dakota. We also have one collection (4 females, partly engorged) from Quetico, Ontario, one from "Ontario," and one female from the short-tailed shrew taken July 10, 1933, from Gaspé, Quebec. No doubt more intensive collecting of ticks from rodents throughout the Northern States will show the species to be rather widely distributed in that section of the country.

Under the mild climatic conditions prevailing in western Washington and Oregon, adults are found on animals there throughout the year. The collection from Quetico, Ontario, was made on February 1, 1932. Immature stages have not been taken on animals by the authors later than the end of October.

Hosts

The wood rat (*Neotoma occidentalis*) is the type host. The species is generally regarded as a rodent parasite. Our records, however, indicate that the adults not infrequently attack the larger mammals, including man. Hadwen (1911) has pointed out that the male is seldom found on hosts but probably stays in the nests of rodents; our records bear this out, as we have only 4 lots (5 specimens) of males taken on hosts. The largest number of specimens, by far, that we have recorded from one host was 62 larvae, 20 nymphs, and 1 female. These were collected from a pika near Florence, Mont., on June 16, 1910, by W. V. King. Bureau of Entomology and Plant Quarantine records are given in Table 11.

Ixodes angustus var. *woodi* Bishopp

Ixodes angustus var. *woodi* is a southwestern form of *I. angustus*. It is of no known economic importance.

Distribution and Hosts

Extensive collections of ticks from wood rats have not been made but this form has been taken in limited numbers on that host in southwestern Texas. In the localities where these collections were made, wood rats are very abundant, nesting for the most part in clumps of prickly pear (cactus).

The five lots of this tick in the Bureau collection were all taken from the Baird wood rat, *Neotoma micropus*. Other collection data on these specimens are as

TABLE 11.—Ixodes angustus, Ixodes auritulus, *and* Ixodes brunneus: *Host records of the Bureau of Entomology and Plant Quarantine*

Host	Lots	Larvae	Nymphs	Males	Females
			Ixodes angustus		
Bat, little brown	1	.....	.....	.....	1(1s)
Cat	1	.....	.....	.....	1(1p)
Chipmunk, Townsend	2	.....	.....	.....	2(4up)
Dog	3	.....	1(1p)	.....	2(2sp)
Gopher	1	.....	.....	.....	1(1s)
Ground squirrel	2	.....	2(8up)	.....	.....
Ground squirrel, Columbian	1	(1p)	1(2p)	.....	.....
Ground squirrel, Douglas	2	.....	.....	.....	2(2p)
Man	3	.....	.....	.....	3(up)
Mouse, red-backed	1	.....	.....	.....	1(1p)
Mouse, redwood white-footed	7	1(2s)	4(+s)	.....	5(6p)
Mouse, Townsend meadow	2	.....	.....	.....	2(5sp)
Pika	3	3(70p)	3(30up)	.....	3(5p)
Pocket gopher, Columbia	1	.....	1(3sp)	.....	.....
Rabbit	2	.....	1(4sp)	1(2)	2(6sf)
Rat, roof	1	.....	.....	.....	1(2p)
Shrew	1	.....	.....	.....	1(1p)
Shrew, Olympic	1	.....	.....	.....	1(1p)
Shrew, short-tailed	1	.....	.....	.....	1(1s)
Shrew, Trowbridge	1	.....	.....	.....	1(2s)
Shrew, wandering	2	1(2p)	1(2s)	.....	1(1p)
Squirrel, Cascades chickaree	1	.....	.....	.....	1(2p)
Squirrel, redwood chickaree	4	.....	2(6us)	.....	4(24up)
Squirrel, Richardson red	1	.....	1(1p)	.....	.....
Squirrel, western	5	.....	1(2sp)	3(3)	5(18sp)
Wood rat, Colorado bushy-tailed	1	.....	.....	.....	1(1p)
			Ixodes auritulus		
Finch, California purple	1	.....	.....	.....	1(1p)
Grouse, Oregon ruffed	1	1(1p)	1(2sp)	.....	.....
Junco, Shufeldt's	3	.....	1(1p)	.....	2(2p)
Mouse, meadow	1	.....	1(1)	.....	.....
Robin, western	3	.....	.....	1(1)	2(2p)
Sparrow, fox	1	1(1s)	.....	.....	1(2p)
Sparrow, Kodiak fox	1	.....	1(1s)	.....	.....
Sparrow, rusty song	2	.....	.....	.....	2(3p)
Woodchuck	1	.....	1(1p)	.....	.....
Wren	1	.....	1	.....	.....
			Ixodes brunneus		
Blackbird	1	.....	.....	.....	1(1p)
Blackbird, red-winged	1	.....	1	.....	.....
Catbird	2	.....	.....	.....	2(5sp)
Grackle, purple	2	.....	.....	.....	2(2up)
Jay, coast	1	1(8sp)	1(2u)	.....	.....
Junco	3	.....	.....	.....	3(3f)
Meadowlark	1	1(1s)	.....	.....	.....
Oven-bird	1	1(3u)	.....	.....	.....
Owl, barred	1	.....	.....	.....	1(1f)
Robin	1	1(5sp)	1(1p)	.....	.....
Robin, western	2	1(1p)	1(2p)	.....	1(1u)
Shrike	1	.....	.....	.....	1(1p)
Sparrow, chipping	1	.....	.....	.....	1(1p)
Sparrow, field	1	.....	.....	.....	1(1f)
Sparrow, golden-crowned	1	1(9sp)	1(3s)	.....	.....
Sparrow, Nuttall's	1	.....	.....	.....	1(1f)
Sparrow, song	1	.....	1(1p)	.....	.....
Sparrow, white-throated	11	2(2pf)	7(11uf)	1	3(3uf)
Starling	1	.....	.....	.....	1(3f)
Swallow, violet-green	1	.....	.....	.....	1(1f)
Thrasher, brown	2	.....	1(1f)	.....	1(1s)
Thrush, hermit	3	1(1s)	1(2sp)	.....	2(2up)
Towhee (including red-eyed and white-eyed)	12	5(12sf)	8(16sf)	.....	2(3p)
Waxwing, cedar	1	.....	.....	.....	1(2p)
Wren, Carolina	2	1(3p)	1(2sp)	.....	.....

follows: Two larvae, 2 nymphs, February 7, 1910, Sabinal, Tex., all slightly to partly engorged. Two females, partly engorged, May 10, 1910, Sabinal, Tex. Three nymphs slightly to partly engorged and 2 females slightly engorged, May 18, 1910, Sabinal, Tex. Three nymphs partly engorged, May 31, 1910, Sabinal, Tex.

The above-mentioned lots were collected by F. C. Pratt and C. T. Atkinson. Two nymphs partly engorged April 6, 1914, Uvalde, Tex., D. C. Parman, collector. See Fig. 10.

Ixodes auritulus Neum.

Ixodes auritulus is an uncommon species occurring largely on birds. It is of no known economic importance.

Distribution

Ixodes auritulus was described from specimens taken on birds from the Straits of Magellan and Tierra del Fuego, South America. In North America it has been collected mainly in the extreme northwestern States and the southwestern Provinces of Canada, although we have one nymph that we consider to be this species, collected on meadow mouse at Temagami, Ontario, September 7, 1934. Our collections have come from three localities in Oregon, viz., Tillamook, Netarts, and Adel, with one collection from Spruce, Wash. (Fig. 10). These collections were made in January, February, March, April, July, and November. The species appears to be largely restricted to the moist coastal area.

Hosts

As stated above, most of our collections have been from birds, the two exceptions being 1 lot from woodchuck and 1 lot from meadow mouse. Hadwen (1916), who first reported the tick from North America, recorded 1 female from Alaska bald eagle (*Haliaeetus leucocephalus alaskanus* Townsend) and 1 male and 10 larvae from Queen Charlotte jay (*Cyanocitta stelleri carlottae*), Queen Charlotte Islands, British Columbia, June 23, 1910. Philip (1933) records the collection of an engorged female from an English sparrow near Hebo, Ore., August 25, 1932. Hearle (1938) states that in the coastal district of British Columbia it appears to be the commonest tick on blue grouse and willow grouse. Table 11 shows the Bureau records for *Ixodes auritulus*.

Ixodes brunneus Koch

Ixodes brunneus is an interesting bird tick that occurs in North America, Europe, and Africa. The species confines its attack to birds, and it is unusual to find more than a very few specimens on any one host. Despite the small numbers present, they frequently appear to have a markedly adverse effect on the host. The authors have several records in which birds have been found dead or unable to fly, with an engorged female of this species attached to the neck or head, usually around the eyes. This has occurred in the case of a swallow, a snowbird (*Junco h. hyemalis*), and certain warblers.

In the case of the swallow, the bird was observed to fall from an overhead wire at Harrisburg, Ore., in April 1932. Upon examination the fully engorged female tick was found attached to the neck. The bird died soon after the parasite was removed.

All the birds affected appeared normal except for the presence of the ticks, and it is suggested that the ill effects may be due to a toxin introduced as the ticks become engorged.

Distribution

This tick is found largely on migratory birds and apparently remains attached for a considerable period, thus giving an opportunity for wide dissemination. The species

has been recorded from many parts of the world, including England, Italy, France, Nyassaland, and many parts of the United States. The species doubtless occurs in Mexico and Canada as well. As indicated by the map (Fig. 12) our collections were all made near the coasts of the Atlantic or Pacific Oceans, or the Gulf of Mexico.

Hosts

All active stages, except the male (which is undescribed), have been collected on birds of many species. However, we are including in the records one male, taken by itself, on a white-throated sparrow at Summerville, S. C., by William P. Wharton. We consider this specimen to be *Ixodes brunneus,* as it agrees well with the specific characters of the female.

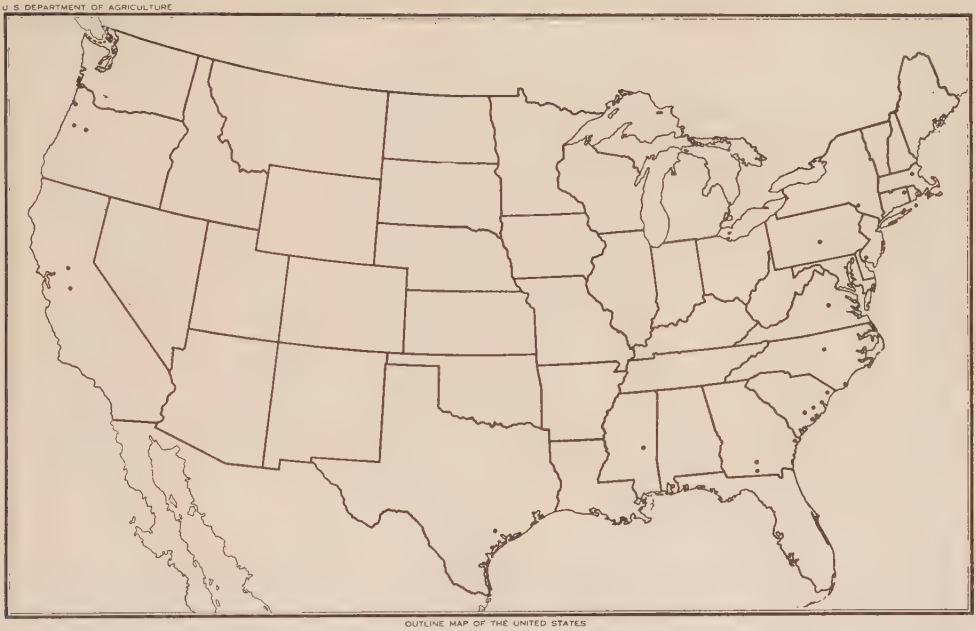

FIG. 12. Distribution of *Ixodes brunneus* in the United States, as indicated by collections of the Bureau of Entomology and Plant Quarantine.

Nuttall and Warburton (1911) summarized the collection records published up to that time, and listed several hosts not represented in the Bureau collections. Our collections, given in Table 11, contain specimens taken on birds every month except May and June. The fact that less bird banding and collecting are done during early summer probably accounts for the absence of records in those months.

Ixodes cookei Pack.

Ixodes cookei is not of great economic importance, as it is not known to transmit disease or to annoy man or other animals seriously. The long mouth parts, characteristic of all *Ixodes,* make this species especially troublesome when it does attach to man. The mouth parts are frequently broken off in the tissues of the host.

Distribution

Ixodes cookei is a widely distributed species (Fig. 13), but most of our collec-

tions have come from the eastern part of the United States. Eight of the 11 lots recorded here from man are from the New England States; 2 are from Pennsylvania, and 1 from Quebec.

Hosts

Wild mammals are the chief hosts, although a number of adult ticks have been collected from dogs and several from man. All stages are found on animals through-

TABLE 12.—Ixodes cookei, I. cookei *var.* rugosus, I. dentatus *and* I. diversifossus: *Host records of the Bureau of Entomology and Plant Quarantine*

Host	Lots	Larvae	Nymphs	Males	Females
			Ixodes cookei		
Cat, civet	1	.....	.....	.....	1(1p)
Cat, domestic	2	.....	.....	.....	2(2p)
Cattle	3	.....	.....	1(1)	2(2pf)
Cougar, Oregon	1	.....	.....	.....	1(1)
Dog	29	1(1)	11(+)	.....	18(+up)
Ferret	1	.....	1(3p)	.....	.....
Fox	3	.....	2(10sf)	.....	1(1p)
Fox, gray	9	5(58sf)	6(10uf)	.....	4(10sf)
Ground squirrel, brown	1	.....	.....	1(1)	1(1s)
Ground squirrel, striped	1	.....	1(11s)	.....	.....
Man	11	.....	5(+up)	.....	8(+sp)
Mink	7	2(+up)	4(+pf)	.....	5(+sf)
Mouse, "field"	1	.....	.....	.....	1(+s)
Mouse, northern golden	1	1(1p)	.....	.....	.....
Opossum	8	1(6f)	6(+sp)	.....	1(1s)
Porcupine	2	.....	.....	.....	2(6pf)
Prairie dog	2	.....	2(5u)	.....	.....
Raccoon, eastern	3	1(13sp)	3(+sp)	.....	1(1p)
Skunk	6	.....	4(51pf)	.....	4(9sp)
Skunk, Alleghenian spotted	2	.....	2(2p)	.....	1(3sp)
Skunk, Florida	6	1(15uf)	2(+150)	1(5)	5(154sp)
Skunk, Rio Grande spotted	1	.....	1(10pf)	.....	1(1s)
Squirrel, fox	1	.....	1(+s)	.....	.....
Squirrel, gray	2	.....	2(+10p)	1(1)	.....
Weasel	7	2(12sf)	5(14sp)	.....	4(5p)
Weasel, New York	2	.....	1(2p)	.....	1(1s)
Woodchuck	6	1(38sp)	5(1247sf)	.....	4(8sp)
Woodchuck, pallid yellow-bellied	1	.....	1(3p)	.....	.....
Woodchuck, southern	1	1(4)	1(2f)	.....	.....
Woodchuck, yellow-bellied	1	1(18sp)	.....	.....	1(2p)
			Ixodes cookei var. *rugosus*		
Dog	10	2(2p)	6(29uf)	.....	5(10sp)
Ground squirrel, Columbian	1	.....	.....	.....	1(1p)
Weasel	1	.....	.....	.....	1(2p)
			Ixodes dentatus		
Mouse, meadow	3	1(1)	2(3sp)	.....	.....
Muskrat	3	2(3pf)	.....	1(1)	.....
Quail, bobwhite	1	1(1p)	.....	.....	.....
Rabbit, cottontail (including New England cottontail and eastern cottontail)	143	89(6407uf)	89(1097uf)	41(311)	51(560uf)
Sheep	1	.....	1(1s)	.....	.....
Sparrow, song	1	1(1u)	.....	.....	.....
Sparrow, white-crowned	1	.....	1(1u)	.....	.....
Thrasher, brown	2	1(1f)	1(3s)	.....	.....
			Ixodes diversifossus		
Chipmunk, Townsend	1	.....	.....	.....	1(1p)
Cow	1	.....	.....	.....	1(1s)
Hare, various species	2	.....	.....	.....	2(3pf)
Rabbit, cottontail	8	1(29pf)	1(1f)	3(8)	6(27uf)
Rabbit, jack (including black-tailed and Washington)	7	.....	1(1p)	3(18)	6(22sf)
Rabbit, Rocky Mountain cottontail	2	.....	1(2pf)	1(7)	2(26sf)
Sparrow, valley fox	1	.....	1(1s)	.....	.....
Wood rat	1	.....	.....	.....	1(1p)

out the year in the southern half of the country. We have specimens of nymphs taken in Rochester, N. Y., on December 21, 1917, and 2 females taken on weasel December 28, 1932, and 1 female on weasel, January 14, 1933, in Pennsylvania. In the Northern States, however, it is most abundant on hosts in midsummer.

Bureau of Entomology and Plant Quarantine records are given in Table 12.

Ixodes cookei var. *rugosus* Bishopp

Ixodes cookei var. *rugosus* is apparently of no economic significance although it may occur on dogs in moderate numbers in all motile stages.

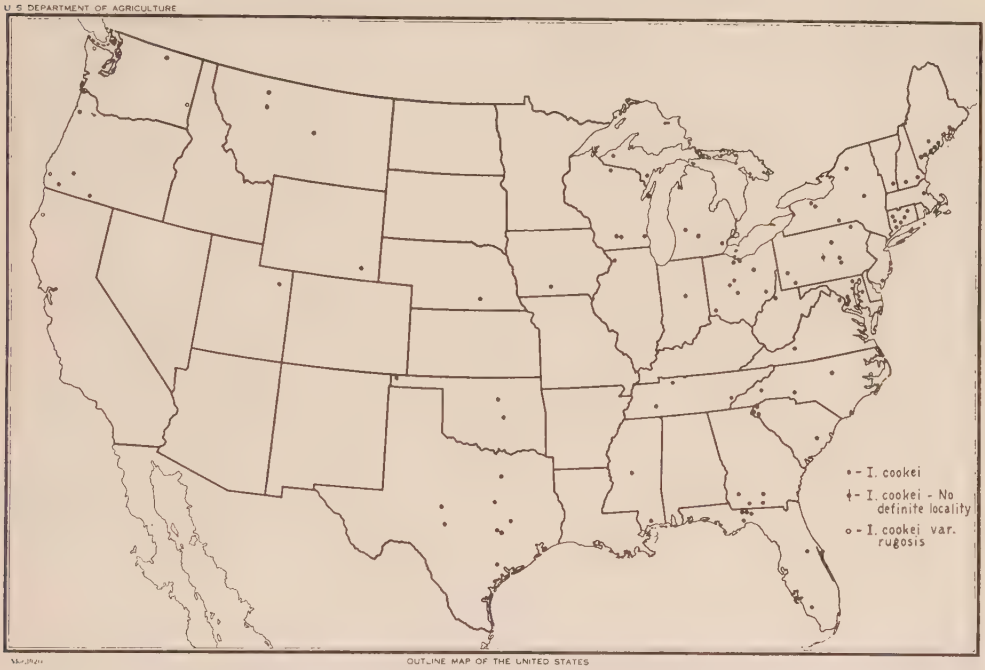
U. S. DEPARTMENT OF AGRICULTURE
• - I. cookei
+ - I. cookei - No definite locality
o - I. cookei var. rugosis
OUTLINE MAP OF THE UNITED STATES

FIG. 13. Distribution of *Ixodes cookei* and *I. cookei* var. *rugosus* in the United States, as indicated by collections of the Bureau of Entomology and Plant Quarantine.

Distribution and Hosts

All the specimens (10 lots) in the collection of the Bureau of Entomology and Plant Quarantine are from western Washington and Oregon (see Fig. 13).

Larvae were collected in March, nymphs in March, May, September, November, and December, and females in March, May, July, September, and November.

The collection records of the Bureau of Entomology and Plant Quarantine are summarized as shown in Table 12.

Ixodes dentatus Neum.

The species *Ixodes dentatus* confines its attack rather closely to cottontail rabbits and appears to be of little economic importance, although it may serve as a carrier of tularemia among rabbits. It is frequently found on these animals in sufficient numbers to cause much irritation and loss of blood.

At present, there is some confusion as to the identity of *Ixodes dentatus* and *I. diversifossus,* as will be explained in the discussion of the latter species.

Distribution

Ixodes dentatus was described from specimens in the Marx collection taken in Maryland from rabbit. It is particularly abundant along the coast from Maryland to Massachusetts (Fig. 14). Numerous collections made by C. N. Smith, M. M. Cole, and H. K. Gouck on Martha's Vineyard, Mass., show the species to be very plentiful there.

Hosts

Ixodes dentatus is found almost exclusively on wild mammals. The rabbit is the type host, and it is certainly the preferred one. The writers, however, have 5

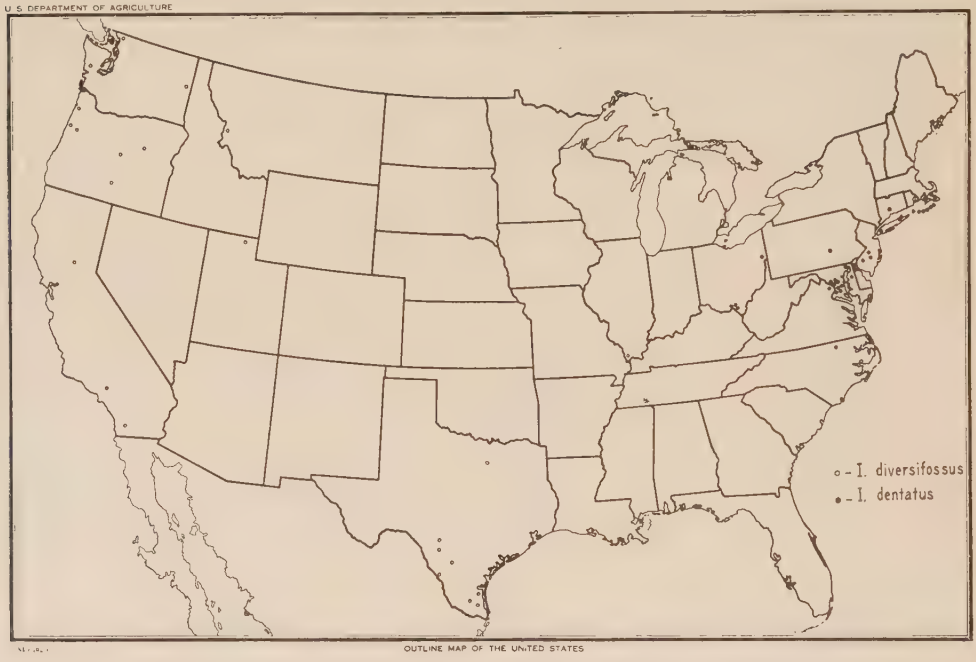

FIG. 14. Distribution of *Ixodes diversifossus* and *I. dentatus* in the United States, as indicated by collections of the Bureau of Entomology and Plant Quarantine.

lots of larvae and nymphs, totaling 7 specimens, which they consider to be this species, taken on birds. The Bureau collections given in Table 12 contain specimens taken on hosts every month of the year. Quite often all stages are found together on the same host. Males are much less numerous on hosts than are females, and they were collected only from April to July, inclusive. The maximum abundance was in April. The species is frequently found on cottontail rabbits in very large numbers. For instance, one rabbit collected by C. N. Smith at Edgartown, Mass., on May 5, 1940, carried 733 larvae, 205 nymphs, 55 males, and 91 females. One lot of 4 fully engorged larvae were collected in a grass clump on February 24, 1940, at Arlington, Va. Only one individual of the species, a slightly engorged nymph, was collected on a cloth drag.

Ixodes diversifossus Neum.

The rabbit appears to be the preferred host of all stages of *Ixodes diversifossus*. At times this tick becomes sufficiently abundant on rabbits to cause some ill effects.

It is not infrequently associated with the rabbit tick (*Haemaphysalis leporis-palustris*) on rabbits. It is rarely found on domestic animals, and it is therefore of little economic importance, although it may play a part in transmitting tularemia among rabbits.

Distribution

This is a North American species found mainly in the western half of the United States. It probably occurs in northern Mexico and southwestern Canada. The type specimens were from New Mexico. There has been some confusion involving this and related species, and this confusion is not yet entirely cleared. It appears that, in general, *Ixodes dentatus* is found in the East, and *I. diversifossus* in the western and southwestern part of the country. For the present purpose we are regarding the specimens from the West and Southwest as *I. diversifossus*. The accompanying map (Fig. 14) indicates the distribution of *diversifossus* and *dentatus*. Cooley and Kohls (1942) regard the form found in the Northwest as a species (*spinipalpis* Nuttall) distinct from *diversifossus* and *dentatus*.

Hosts

Host records obtained by the Bureau of Entomology and Plant Quarantine indicate that the species confines its attack almost wholly to mammals. We have only one specimen from a bird host. This is a slightly engorged nymph collected on a valley fox sparrow, March 5, 1930, at Netarts, Ore., by Alex and Rosaline Walker.

Specimens have been taken on hosts every month of the year except August. Larvae and nymphs are not commonly found on hosts, and the collections containing them were taken in the spring, fall, and winter. Bureau of Entomology and Plant Quarantine records are given in Table 12.

Ixodes kingi Bishopp

The Rotund Tick

The rotund tick is of no recognized economic importance except as a parasite of dogs and certain fur-bearing animals. However, like many other ticks it may at times be concerned with the transmission among animals of such diseases as tularemia and Rocky Mountain spotted fever.

Distribution

The type locality of *Ixodes kingi* is Meeteetse, Wyo. Some Bureau records on the distribution of this species have been published by Bishopp (1911a). These and more recent records are indicated on the accompanying map (Fig. 16). It will be noted that the species is found mainly in the western half of the United States. It has been recorded from Medicine Hat, Alberta, by Hearle (1938), and with little doubt it occurs also in northern Mexico.

Hosts

The type host is badger, and this appears to be a preferred host since next to the dog the largest number of collections and of specimens recorded in our files are from that host. The species is seldom found in any considerable numbers on any host.

All stages were taken on hosts practically throughout the year, although they appear to be most abundant during spring and early summer. The Bureau collections are shown by hosts in Table 13.

TABLE 13.—Ixodes kingi, I. muris, *and* I. ricinus californicus: *Host records of the Bureau of Entomology and Plant Quarantine*

Host	Lots	Larvae	Nymphs	Males	Females
	Ixodes kingi				
Badger	6	.....	1(4p)	4(10)	6(54sp)
Dog	20	.....	1(1p)	4(10)	20(58uf)
Ferret, black-footed	1	.....	.....	.....	1(1s)
Fox, red	1	.....	.....	.....	1(1p)
Ground squirrel, Columbian	2	1(6u)	1(4s)	.....	.....
Mink	2	.....	.....	.....	2(4p)
Pocket gopher (*Thomomys* sp.)	4	.....	.....	1(1)	4(4p)
Pocket mouse, Oregon	1	.....	.....	.....	1(1p)
Prairie dog	4	.....	1(3sp)	1(1)	2(2u)
Rabbit, cottontail	1	.....	.....	.....	Several
Raccoon	1	1(2f)	1(1p)	.....	.....
Rat, kangaroo	1	.....	.....	1(1)	.....
Skunk	1	.....	1(25up)	.....	.....
Skunk (*Compaties lemonatus texanus*)	2*	.....	1(4p)	.....	.....
Skunk (*Mesomelas longata*)	3	.....	2(5sf)	.....	3(15sf)
Skunk (*M. mesomelas varians*)	1	.....	.....	.....	1(3p)
Wolf	1	.....	.....	.....	1(1p)
Woodchuck	2	.....	1(3p)	.....	1(1s)
Woodchuck, pallid yellow-bellied	3	.....	2(2s)	.....	1(5p)
Wood rat	1	1(3sp)	.....	.....	.....
	Ixodes muris				
Dog	2†	.....	.....	.....	1(1p)
Man	1	.....	1(1)	.....	.....
Mouse, jumping	3	.....	2(3up)	.....	.....
Mouse, meadow (including Pennsylvania meadow mouse)	13	5(8u)	6(18u)	1(1)	6(23up)
Mouse, white-footed	4	1(1u)	3(5)	.....	2(3)
Muskrat	3	.....	3(4f)	.....	1(1f)
Rabbit, cottontail	6	1(3f)	1(2)	2(6)	5(11uf)
Rat	1	1(2u)	.....	.....	.....
Rat, Norway	3	2(2f)	.....	.....	.....
Shrew, long-tailed	1	1(5)	1(2)	.....	.....
Shrew, short-tailed	1	.....	.....	.....	1(1)
	Ixodes ricinus californicus				
Bobcat	4	.....	.....	3(9)	4(6uf)
Burro	1	.....	.....	.....	1(2sp)
Cat, domestic	1	.....	.....	.....	1(1p)
Cattle	14	.....	.....	6(14)	14(72uf)
Cougar	3	.....	.....	1(8)	3(13sp)
Coyote	5	.....	.....	2(4)	4(12uf)
Deer	3	.....	.....	3(21)	3(24up)
Deer, black-tailed	2	.....	.....	2(18)	2(7sp)
Dog	34	.....	1(5pf)	16(34)	34(123up)
Ground squirrel	1	.....	1(1s)	.....	.....
Grouse	1	1(8f)	1(12sp)	.....	.....
Horse	18	.....	1(1)	6(6)	15(+26sp)
Lizard (*Sceloporus o. occidentalis*)	2	.....	2(6sp)	.....	.....
Man	22	.....	.....	8(14)	26(36up)
Mouse, meadow	1	.....	1(1u)	.....	.....
Mouse, southern parasitic	1‡	.....	.....	.....	.....
Mouse, spiny pocket	1	1(7sf)	.....	.....	.....
Mule	2	.....	.....	1(1)	2(3s)
Owl, burrowing	1	1(1p)	.....	.....	.....
Rabbit	1	.....	.....	1(2)	.....
Rabbit, Colorado desert jack	1	.....	.....	1	.....
Rabbit, cottontail	1	.....	.....	.....	1(1s)
Rabbit, jack	3	1(1f)	.....	.....	2(2sp)
Wolf, timber	2§	.....	.....	1(1)	1(2sp)
Wood rat, large-eared	1	.....	1(1s)	.....	.....

* One lot included "2 ticks."
† One lot included "6 ticks."
‡ One tick. § Eight hides examined.

Ixodes marxi Banks

Marx Tick

The Marx tick is of no recognized economic importance, and it is certainly a relatively rare species. The collections of the Division of Insects Affecting Man and Animals of the Bureau of Entomology and Plant Quarantine contain only eight lots; and eight (females) was the maximum number taken on any one host (gray squirrel, by E. B. Marshall). The male is unknown and apparently does not attach to hosts.

Distribution and Hosts

In describing the species, Banks (1908) records specimens taken on red squirrel in Washington, D. C., Salineville and Wauseon, Ohio, Ithaca, N. Y., Portland, Mich., and Guelph, Ontario, and on fox in Denver, Colo.

The records on some of the above-mentioned collections and subsequent ones (Bureau of Entomology and Plant Quarantine data) are: Gray squirrel: Laurel, Md., September 15, 1932, numph (1 slightly engorged), females (2 partly engorged); Langley Park, Md., January 15, 1937, females (8 partly engorged); Nile Township, Scioto County, Ohio, October 3, 1936, female (1 partly engorged); Dauphin County, Pa., March 27, 1940, nymph (1 slightly engorged), female (1 slightly engorged). Red squirrel: Webster, N. Y., October 1915, female (1 unengorged); Ashtabula, Ohio, September 16, 1937, females (5 partly engorged); Faulkland, Del., May 20, 1941, female (1 slightly engorged); Toronto, Canada, August 26, 1923, female (1 slightly engorged).

Hearle (1938) states that specimens that agree very closely with the description of this species have been found in the Kamloops and Nicola districts and the North Thompson Valley in British Columbia. These were taken almost entirely on the pine squirrel.

Ixodes muris Bishopp & Smith

The Mouse Tick

The mouse tick is of no recognized economic importance. It is possible that it may play a part in the transmission of disease among rodents. It appears never to be very abundant, as indicated in the statement by Bishopp and Smith (1937) that on 103 rodents were found 1 larva, 25 nymphs, 1 male, and 24 females.

Distribution

This species has been collected only on the southern side of Cape Cod and the adjacent islands of Martha's Vineyard and Nantucket, with the exception of a single lot from Melvin Village, N. H.

Hosts

This tick was taken on hosts during the period April to October only.

The predominant hosts are mice, but occasionally this species attaches to other mammals as shown by the Bureau of Entomology and Plant Quarantine records in Table 13.

Ixodes ricinus californicus Banks

The California Black-Legged Tick

The California variety of the European *Ixodes ricinus* is of distinct importance as a pest of man, domestic animals, and deer along the West Coast from Mexico into

British Columbia. In some localities it is the dominant wood tick, and it may well be concerned in the transmission of rickettsial or other diseases of man and animals.

Cooley and Kohls (1943) state that Banks' type of *Ixodes californicus* is not specifically identical with the form that has been generally referred to as *I. californicus* or *I. ricinus californicus* in the literature (and to which we refer here). They propose a new name, *Ixodes pacificus,* for this form.

Distribution

This form is common in the Pacific States, mainly west of the Cascade Range (Fig. 15). Its range extends into British Columbia and southward into Lower California. One of the Utah records shown on the map represents a female tick that

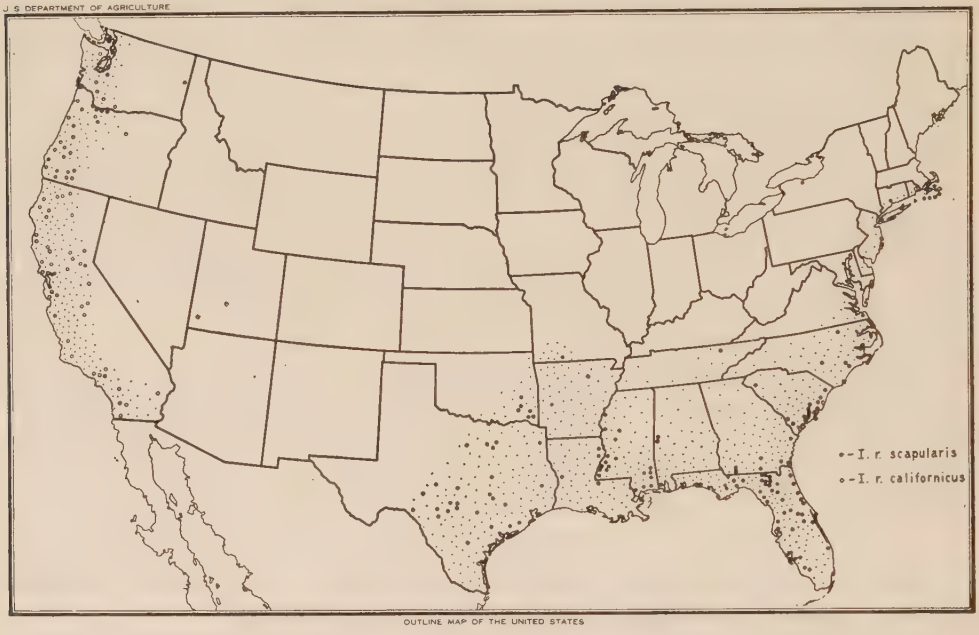

FIG. 15. Distribution of *Ixodes ricinus scapularis* and *I. r. californicus* in the United States. Large dots and circles indicate localities from which specimens are herein reported. Small dots indicate probable distribution of species.

attached, on October 20, 1938, to the armpit of a hunter, who may have picked it up from a deer which he had killed. Gerald Thorne who collected this specimen writes: "No additional collections of *Ixodes ricinus californicus* have been made since the first one in 1938. We hunted in the same area (Birch Creek, southwest of Circleville, Utah) in 1939, 1940, and 1941, and I examined deer and porcupines for additional specimens but without success. Milo H. Denning of the Forest Service recalled that about 1930 he found a similar tick 20 miles southwest of Circleville attached at the belt line."

The other record on the map refers to two female ticks submitted by Dr. Don Rees. These attached to a man on a deer hunt near Pinto, Utah, October 20, 1938. These may well have come from a deer. Both the immature and adult stages are most abundant in winter, spring, and early summer. None of the collections of the Bureau was made in August and September, and a few in July and October.

Hosts

The adults of the California black-legged tick have a rather broad host range among mammals. In addition to attacking mammals, the immature stages attach to cold-blooded animals, such as lizards, and occasionally are found on birds.

Bureau host records are given in Table 13.

Ixodes ricinus scapularis Say

The Black-Legged Tick

Although not known to be concerned in the transmission of any disease, the black-legged tick is of considerable importance as a parasite of many animals, including man. Its long mouth parts inflict a noticeable wound and are often broken off in the tissues when the tick is removed. This form is generally regarded as a variety of the European *Ixodes ricinus*. However Cooley (1944) in an article received as this goes to press, apparently considers *scapularis* a distinct species. He also described in this paper a new species (*Ixodes ozarkus*) from dogs in Arkansas. We think we have included among our records of *I. r. scapularis,* specimens of this form (*I. ozarkus*) which is very closely related to *scapularis*.

Distribution

The black-legged tick is found from southern Massachusetts southward to Florida, and from Indiana and Iowa south to Louisiana and Texas (Fig. 15). A few specimens have been collected in Ontario, Canada (Nuttall, 1911, p. 158). The species also extends into Mexico, and Banks considers as this form some specimens from Costa Rica described by Neumann as *Ixodes affinis*. This tick has been collected by workers of the Bureau of Entomology and Plant Quarantine in every month of the year, but in the South it is most abundant during the fall and spring. During the summer the immature stages are found on hosts more commonly than are the adults.

Hosts

The black-legged tick is a very general feeder on mammals. Cattle, deer, dogs, and hogs are often rather heavily infested. Hooker, Bishopp, and Wood (1912) report the immature stages as collected on quail, blue jay, and thrush, and we here add the towhee. The immature stages attack lizards also.

Collections of the Bureau of Entomology and Plant Quarantine indicate that a considerable number of these ticks are recovered on clothing or on cloths dragged over the vegetation. Other records are shown in Table 14.

Ixodes sculptus Neum.

Ixodes sculptus is parasitic on mammals, particularly on wild species. It is not recognized as being of economic importance, although it may play a part in the transmission of such diseases as tularemia or Rocky Mountain spotted fever. The males are rarely found on hosts. As pointed out by Hixson (1932), the habitat of the species except while on animals is commonly in the burrows of rodents. The engorged ticks leave the hosts at night and burrow into the litter, where copulation, molting, and oviposition take place.

Considerable confusion exists regarding the identity of this species because of a rather close resemblance to certain other species.

TABLE 14.—Ixodes ricinus scapularis, I. sculptus, *and* I. texanus: *Host records of the Bureau of Entomology and Plant Quarantine*

Host	Lots	Larvae	Nymphs	Males	Females
	Ixodes ricinus scapularis				
Bobcat, Florida	3	.....	.....	3(23)	3(25sp)
Cardinal	1	.....	1(1f)	.....	.....
Cat, domestic	4	.....	.....	1(1)	4(6uf)
Cattle	70	.....	.....	29(+76)	69(+235uf)
Deer, Mexican (hide)	1	.....	.....	1(41)	1(31sp)
Deer, white-tailed	65	1(25)	2(10)	54(1197)	66(+1194uf)
Dog	65	1(8)	3(13)	30(+317)	60(+1220)
Fox	3	.....	.....	2(5)	3(26up)
Goat	2	.....	.....	.....	2(+19)
Hog	11	.....	.....	2(3)	10(68uf)
Horse	14	.....	.....	4(14)	14(57uf)
Lizard, red-headed	1	1(1)	1(1p)	.....	.....
Lynx (*Lynx* spp.)	4	.....	.....	1(3)	4(23sf)
Man	21	.....	4(4us)	8(19)	14(29up)
Mouse, cotton	3	2(2s)	1(1s)	.....	.....
Mouse, meadow and white-footed	3	2(27f)	3(12uf)	.....	.....
Mouse, northern white-footed	1	.....	.....	1	.....
Mouse, old-field	1	1(1p)	.....	.....	.....
Mule	2	.....	.....	.....	2(5p)
Opossum	9	.....	.....	3(12)	9(64uf)
Raccoon	10	.....	.....	4(7)	9(16up)
Rat, Norway	1	1(1)	.....	.....	.....
Rat, rice swamp	1	1(3p)	.....	.....	.....
Sheep	4	.....	.....	3(14)	4(40uf)
Skink	1	.....	1(1)	.....	.....
Skink, red-headed	1	.....	1(5up)	.....	.....
Squirrel	2	.....	1(1)	.....	1(1s)
Towhee	2	1(1u)	2(11uf)	.....	.....
Wolf	1	.....	.....	.....	1(2f)
	Ixodes sculptus				
Cat, civet	2	.....	2(11sp)	.....	2(6p)
Cat, domestic	1	.....	.....	.....	1(1p)
Fox, red	1	.....	.....	.....	1(1s)
Goat, domestic	1	.....	.....	.....	1(2sp)
Ground squirrel, Belding	1	.....	.....	.....	1(1)
Ground squirrel (*Citellus* sp.)	1	.....	.....	.....	1(2us)
Ground squirrel, Franklin	1	.....	.....	.....	1(5sp)
Ground squirrel, striped	24	5(+18up)	15(48uf)	4(5)	17(30up)
Man	1	.....	1(2p)	.....	.....
Mole, Misouri Valley	1	.....	.....	.....	1(1p)
Mouse, redwood white-footed	1*	.....	.....	.....	.....
Pocket gopher, brown	2	1(90sf)	1(12p)	.....	2(18p)
Pocket gopher (*Geomys* spp.)	3	.....	.....	1(1)	3(8sp)
Pocket gopher, Illinois	2	.....	.....	1(1)	1(17up)
Pocket gopher, prairie	1	.....	.....	.....	1(4p)
Pocket gopher, Shaw	1	.....	.....	.....	1(4s)
Prairie dog	1	.....	.....	.....	1(2us)
Rabbit	1	.....	.....	.....	1(1p)
Raccoon	1	.....	.....	.....	1(1p)
Skunk	2	.....	2(4sp)	.....	2(3p)
Skunk, "two-lined"	1	.....	.....	.....	1(1s)
Weasel	1	.....	1(1p)	.....	1(1p)
Wood rat	1	.....	1(2p)	.....	1(3p)
	Ixodes texanus				
Bobcat	1	.....	.....	.....	1(1f)
Marten	5	.....	2(3sf)	.....	5(15pf)
Raccoon	30	4(12sf)	15(39sf)	3(4)	23(66sf)
Squirrel	2	.....	1(1p)	.....	2(5p)
Squirrel, pine	5	1(1s)	4(23sp)	.....	3(27sp)
Weasel	3	1(158pf)	2(7pf)	.....	3(4p)

* "1 tick."

Distribution

Ixodes sculptus is rather widely distributed from Illinois, Michigan, and Louisiana westward, but apparently it is not abundant anywhere. The type locality is the Santa Cruz Mountains in California. It has been recorded from Canada, and it may possibly occur in northern Mexico.

Hosts

Burrowing rodents appear to be the preferred hosts. Possibly the predatory habit of some of the larger mammals, such as the skunk and weasel, upon which the tick has been found, accounts for their infestation.

We have but a single record of the occurrence of this species on man, and there is some doubt as to the identity of the specimens (2 nymphs) in this case. This collection was made by O. G. Babcock at Sonora, Tex. on March 30, 1921. Our records show the tick to have been collected on animals in every month of the year. The habit of the tick of spending its non-parasitic life in the burrows of animals would give it protection against unfavorable weather and favor its year-round activity.

Bureau of Entomology and Plant Quarantine host records are given in Table 14.

Ixodes texanus Banks

Ixodes texanus is of no apparent economic importance, as it has been collected only on wild mammals, and even then not in great numbers.

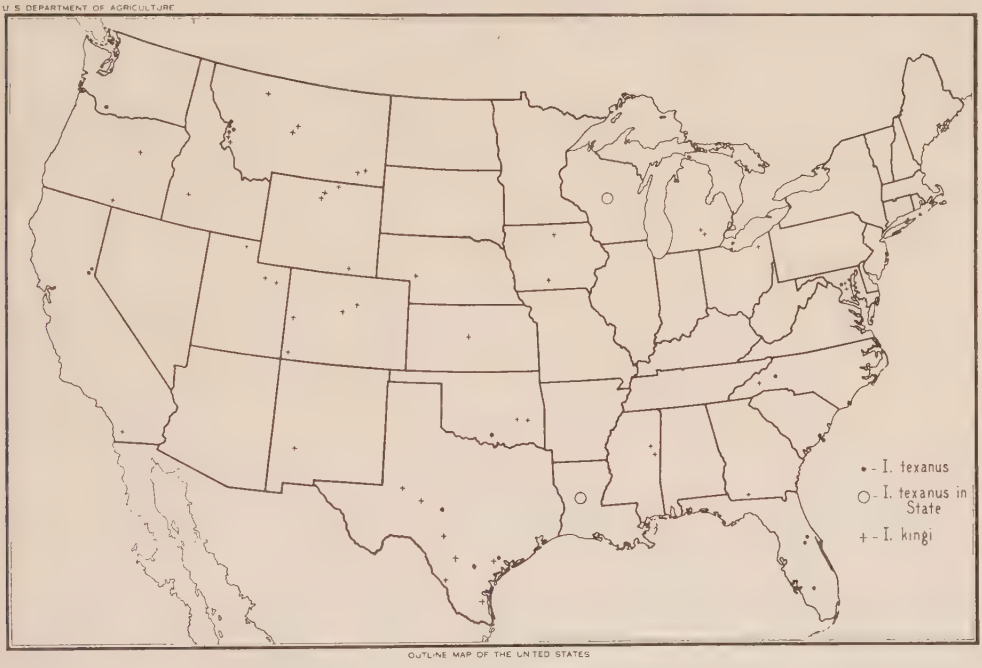

FIG. 16. Distribution of *Ixodes texanus* and *I. kingi* in the United States, as indicated by collections of the Bureau of Entomology and Plant Quarantine.

Distribution

The type locality of this tick is Live Oak County, Texas. The species is widely distributed in the United States and southern Canada. No doubt it occurs in northern Mexico also. The accompanying map (Fig. 16) indicates its distribution in the United States.

Hosts

The type host is raccoon (*Procyon lotor*). This animal appears to be one of the preferred hosts. All our collections have been from wild mammals, but Eddy and

Joyce (1942) report 1 female from a dog in Iowa. This species is found in all active stages on mammals throughout the year. We have specimens collected in every month except October. Most of the collections were taken in the winter, but this is probably because most fur-bearing animals are caught at this time of year.

Males of this species are rarely taken on hosts. Four males in the collections were from three raccoons caught in March and May. On two of these animals the males were associated with females. In 1912 the senior author pointed out that the nymphs collected up to that time were taken only during the period July to November. More recent collections show them, and larvae also, to be on hosts during winter and spring as well. In one case, the comparatively large number of 158 larvae, 4 nymphs, and 1 female were taken on a weasel at Lake Tahoe, Calif. on January 30, 1917. The Bureau host records are given in Table 14.

Ornithodoros megnini Meig.

The Ear Tick

The ear tick, or, as it is sometimes aptly called, "the spinose ear tick," is a native of the Americas. It claims attention as a parasite of all classes of domestic animals, certain of the larger wild mammals, and man.

It is not known to transmit any disease, but its presence is highly irritating and often painful. Since this tick attaches deep in the external ear it is well protected from scratching and also from acaricides applied to livestock as a dip. The irritation produced often leads to attack by screwworms, which sometimes results in disfigurement or death.

Distribution

In its original range, the ear tick was probably confined to the semi-arid and arid Southwestern States and Mexico. Its habit of remaining in the deeper portions of the ears of animals in the larval and nymphal stages for considerable periods (up to 7 months) affords an opportunity for it to be transported long distances with its hosts. Also, the facts that the adults take no food, that they often hide in protected places, and that they continue to deposit eggs over periods of several months permit this pest to spread in stock cars and other vehicles used in hauling livestock.

It appears that the ear tick may survive and breed temporarily in the more humid portions of the Southern States and in the relatively dry and cold northern Rocky Mountain States. The tick was reported in considerable numbers in the ears of horses on a farm near Orlando, Fla. in 1912. Specimens were collected by W. W. Yothers on January 17, and the senior author visited the locality on March 31 and examined four of the horses, one of which had two nymphs in one ear. These horses had been shipped from Alamogordo, N. Mex., during the previous year. Inquiries indicated that although horses were frequently shipped there from normally infested areas of the United States the species had not become established.

In connction with the distribution of *Ornithodoros megnini* by shipments of livestock, it is interesting to note that this species was accidentally introduced into the Karoo and western South Africa, presumably in shipments of horses or mules from the southwestern part of the United States. Bedford (1934, p. 79) states that "It appears to have been observed by Manley in the Cape Colony as far back as 1898." He gives the distribution as "throughout the arid districts of Cape Province and

Orange Free State," also parts of Natal and the Transvaal as far north as the Pretoria District. Bedford (1913) first reported this tick from Africa, and gave Vryburg, Bechuanaland, Fauresmith, Orange Free State, Sudan, the United States, and Mexico as its habitats.

According to a report by J. H. Beaumont (1943), this tick is present in Hawaii. He states that 45 per cent of local cattle examined were infested with from 1 to 65 ticks in each ear.

It is unlikely that *Ornithodoros megnini* will ever become permanently established or assume much importance as a livestock pest in States to the east of Texas and to the north of Oklahoma, New Mexico, Arizona, and California, with the possible exception of certain parts of Southern Colorado, Utah, and Nevada. Cooley and Kohls (1944b), however, record an apparent hold-over for 4 years in Montana,

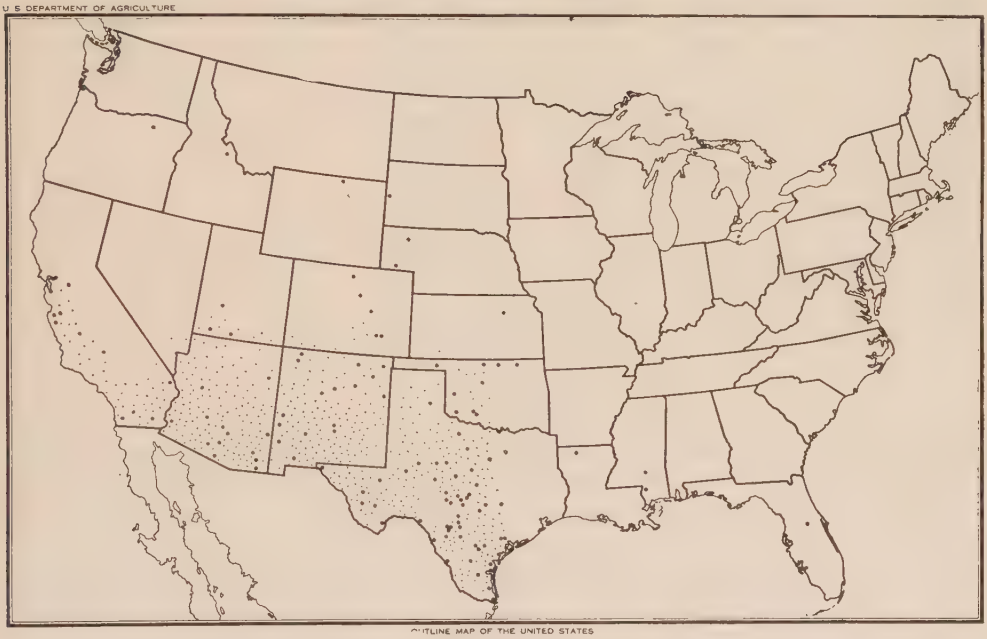

FIG. 17. Distribution of *Ornithodoros megnini* in the United States. Large dots indicate localities from which specimens are herein reported. Small dots indicate probable distribution of species.

from 1912 to 1916. This tick (4 well-engorged nymphs) was collected by J. D. Gregson in December 1943 in the ears of a mountain goat at Bryant Creek, British Columbia. The collection of a nymph on a cat in the same vicinity (Ewings Landing, British Columbia, October 6, 1941) suggests that the species may be established there, at least temporarily. Likewise it will probably never become a serious pest in areas of considerable rainfall. The eastern boundary of the tick's occurrence in numbers is approximately the 97th meridian, as shown on the accompanying map (Fig. 17).

Hosts

As has been mentioned, the ear tick attacks all kinds of large mammals. It is particularly troublesome as a pest of horses, cattle, sheep, and dogs. It is to be found on hosts throughout the year, but its injurious effects are specially noticeable during

winter and spring, particularly following long periods of drought when both the range and the livestock are poor. Theiler (1921) lists the ostrich as a host in addition to the common domestic animals. The six ticks reported on man were all from deep in the external ear. One nymph was said to have been causing pain for 3 months in the ear of a 3-year-old boy.

Table 15 gives the host records in the collection of the Bureau of Entomology and Plant Quarantine.

TABLE 15.—Ornithodoros megnini: *Host records of the Bureau of Entomology and Plant Quarantine*

Host	Lots	Larvae	Nymphs	Males	Females
Ass	6	3(+)	6(+)	.....	.....
Cat	12	1(1f)	11(+uf)	.....	.....
Cattle	114	14(+uf)	110(1566uf)	.....	.....
Cattle flytrap	10*	.....	.....	.....	.....
Coyote	3	.....	3(19sp)	.....	.....
Deer	1	.....	1(6sp)	.....	.....
Deer, white-tailed	3	.....	3(5pf)	.....	.....
Dog	21	1(2)	21(53+uf)	.....	.....
Elk	2	.....	1(4f)	.....	.....
Goat, Angora	1	.....	1(6sp)	.....	.....
Goat, mountain	1	.....	1(1s)	.....	.....
Hog	2	1(+)	2(+4pf)	.....	.....
Horse	20	.....	24(+97)	.....	.....
Man	6	1(1f)	5(6sp)	.....	.....
Mule	1	1(+)	1(+)	.....	.....
Rabbit, cottontail	1	.....	1(1u)	.....	.....
Rabbit, jack	1	.....	1(2p)	.....	.....
Sheep	7	.....	7(+73uf)	.....	.....

* Sixteen males and females.

Rhipicephalus sanguineus Latr.

The Brown Dog Tick

The brown dog tick is a first magnitude pest of dogs. Not only does it cause dogs much discomfort and loss of blood from its irritating bites, but it carries malignant jaundice (*Piroplasma canis*) of dogs in the Mediterranean region and in other parts of the world. This disease has been found in Florida, but it is not known to occur in other parts of the United States. The brown dog tick has been shown capable of carrying Spanish relapsing fever and typhus fever in the Mediterranean area. It has also been found able to transmit, experimentally, several other diseases including *Haematozoon canis, Trypanosoma cruzi, T. christophersi,* Rocky Mountain spotted fever, and anaplasmosis of cattle and dogs.

The brown dog tick is an annoying household pest. When dogs are kept in living quarters this tick often multiplies there, and all active stages are found crawling about the curtains, walls and furniture. Fortunately it does not readily attach to man, and it is not known to carry any disease of man in the United States. Its eradication is difficult.

Distribution

The brown dog tick is widely distributed throughout the tropical and temperate regions of the world. It has been collected on every continent. In the United States it was first found in southern Texas. Hooker, Bishopp, and Wood (1912) reported its occurrence as far north as Jackson and Hays Counties, and as far west as Del Rio, Val Verde County, Tex. Since then it has spread to practically all parts of the country (Fig. 18), but it is still more generally distributed in the Southwest. In the North it is more or less confined to the larger cities where dogs are con-

centrated. The transportation of dogs and their contact in boarding kennels give opportunities for its rapid dissemination. Although this tick occurs normally in the warmer parts of the world, the heated buildings in more northern regions are favorable for its overwintering and continuous development, therefore it is there confined chiefly to urban areas and to buildings. In those parts of the Southwest and in Florida where the climate is favorable it is found almost everywhere—out of doors as well as in buildings.

Hosts

In the United States the dog is almost the exclusive host of the brown dog tick. In other parts of the world it is more general in its feeding habits, for instance it has been reported from dromedary, from fox and other canines, and from birds,

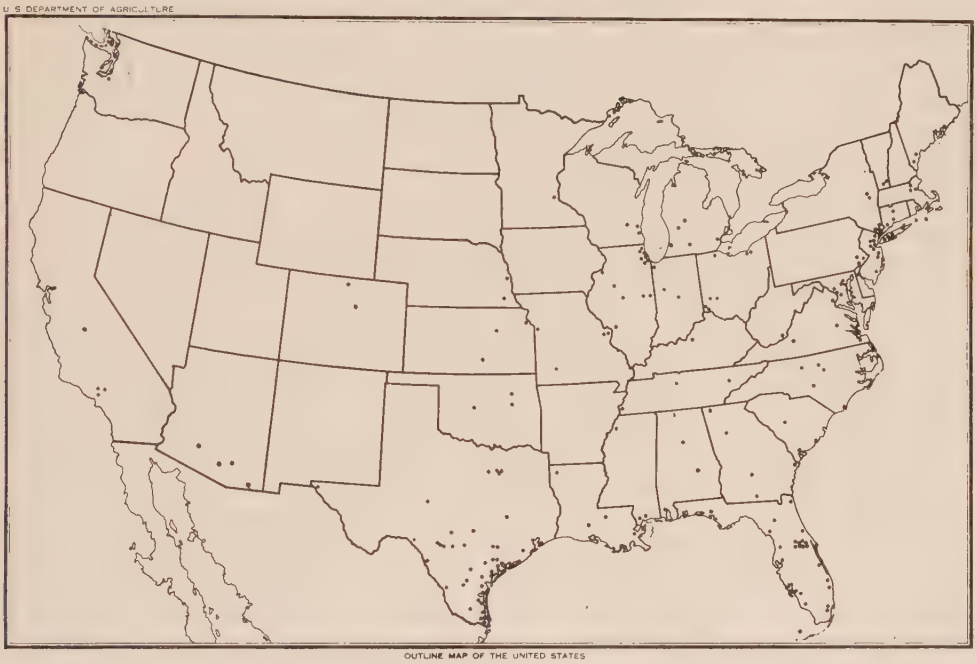

FIG. 18. Distribution of *Rhipicephalus sanguineus* in the United States, as indicated by collections of the Bureau of Entomology and Plant Quarantine.

buffalo, cat, goat, hare, horse, ox, and sheep. We have few United States records from hosts other than the dog, as indicated below. McIntosh (1931) states that the Zoological Division of the Bureau of Animal Industry has one record from a cow in West Palm Beach, Fla.

The Bureau of Entomology and Plant Quarantine collection contains records of one lot of 5 partly engorged females from ass; 408 lots from dog, consisting of numerous specimens of larvae, nymphs, and adults, in all stages of engorgement; 3 lots from rabbit, consisting of 2 males, 3 females, and 5 listed as "ticks." Two lots were sent in by correspondents with the report that they were taken from man; these consisted of 4 fully engorged larvae, 6 unengorged to fully engorged nymphs, 3 males, and 8 unengorged to fully engorged females. We consider these records from man doubtful.

COMMON AND SCIENTIFIC NAMES OF HOSTS

Common Name	*Scientific Name*
Antelope, American pronghorn	*Antilocapra a. americana*
Badger	*Taxidea taxus*
Blackbird, Brewer's	*Euphagus cyanocephalus*
Blackbird, red-winged	*Agelaius phoeniceus*
Bluebird, western	*Sialia mexicana occidentalis*
Boa, Mexican	
Bobcat	*Lynx rufus*
Bobcat, Florida	*Lynx rufus floridanus*
Bunting, painted	*Passerina ciris*
Caribou	*Rangifer* sp.
Catbird	*Dumetella carolinensis*
Chaparral cock	*Geococcyx californianus*
Chickaree, Douglas	*Sciurus d. douglasii*
Civet cat	*Bassariscus astutus*
Cony (see Pika)	
Cowbird	*Molothrus ater*
Chipmunk, buff-bellied	*Eutamias amoenus luteiventris*
Chipmunk, Colorado	*Eutamias q. quadrivittatus*
Chipmunk, Merriam	*Eutamias merriami*
Chipmunk, painted	*Eutamias minimus pictus*
Chipmunk, Townsend	*Eutamias t. townsendii*
Coyote, Great Basin	*Canis lestes*
Crow, southern	*Corvus brachyrhynchos paulus*
Ctenosaura, spiny	*Ctenosaura acanthura*
Deer, black-tailed	*Odocoileus columbianus* subsp.
Deer, mule	*Odocoileus hemionus* subsp.
Deer, Rocky Mountain	*Odocoileus h. hemionus*
Deer, Virginia	*Odocoileus v. virginianus*
Deer, white-tailed	*Odocoileus virginianus* subsp.
Elk (wapiti), western	*Cervus canadensis occidentalis*
Ferret, blackfooted	*Mustela nigripes*
Finch, California purple	*Carpodacus purpureus californicus*
Fox, Florida gray	*Urocyon cinereoargenteus floridanus*
Fox, gray	*Urocyon cinereoargenteus*
Fox, red	*Vulpes* sp.
Goat, mountain	*Oreamnos americanus*
Grackle, purple	*Quiscalus q. quiscula*
Ground squirrel	*Citellus* spp.
Ground squirrel, Belding	*Citellus beldingi*
Ground squirrel, California or Beechey	*Otospermophilus grammurus beecheyi*
Ground squirrel, Columbian	*Citellus c. columbianus*
Ground squirrel, Douglas	*Otospermophilus grammurus douglasii*
Ground squirrel, Franklin	*Citellus franklini*
Ground squirrel, gilded	*Callispermophilus chrysodeirus*

Common Name	*Scientific Name*
Ground squirrel, little gray	*Citellus m. mollis*
Ground squirrel, Montana mantled	*Callispermophilus lateralis cinerascens*
Ground squirrel, Oregon	*Citellus oregonus*
Ground squirrel, striped	*Citellus tridecemlineatus*
Ground squirrel, Wyoming	*Citellus elegans*
Grouse, Oregon ruffed	*Bonasa umbellus sabini*
Grouse, ruffed	*Bonasa umbellus*
Hawk, marsh	*Circus hudsonius*
Hawk, sparrow	*Falco sparverius*
Hawk, Swainson's	*Buteo swainsoni*
Heron, little green	*Butorides v. virescens*
Iguana, ctenosaura	*Ctenosaura multispinosus*
Jay, coast	*Cyanocitta stelleri carbonacea*
Junco, Shufeldt's	*Junco hyemalis connectens*
Killdeer	*Oxyechus v. vociferus*
Leopard-cat	*Felis pardalis griffithii*
Lion, Mexican	*Felis hippolestes aztecus*
Lion, mountain	*Felis concolor*
Lizard	*Sceloporus undulatus*
Lizard	*Sceloporus o. occidentalis*
Marten	*Martes* sp.
Meadowlark, southern	*Sturnella magna argutula*
Mink, Florida	*Mustela vison lutensis*
Mockingbird	*Mimus polyglottos*
Mole, common	*Scalopus aquaticus*
Mole, Missouri Valley	*Scalopus aquaticus machrinoides*
Mole, prairie	*Scalopus aquaticus machrinus*
Moose	*Alces americana*
Mouse, Baird	*Perognathus f. flavus*
Mouse, Cary	*Microtus montanus caryi*
Mouse, cotton	*Peromyscus g. gossypinus*
Mouse, Gambel white-footed	*Peromyscus maniculatus gambeli*
Mouse, house	*Mus m. musculus*
Mouse, meadow	*Microtus* sp.
Mouse, northern golden	*Peromyscus n. nuttalli*
Mouse, northern white-footed	*Peromyscus leucopus noveboracensis*
Mouse, old-field	*Peromyscus p. polionotus*
Mouse, Oregon pocket	*Peromyscus p. parvus*
Mouse, parasitic	*Peromyscus c. californicus*
Mouse, pine	*Pitymys* sp.
Mouse, pocket	*Perognathus* sp.
Mouse, red-backed	*Evotomys gapperi*
Mouse, redwood white-footed	*Peromyscus maniculatus rubidus*
Mouse, Rocky Mountain jumping	*Zapus p. princeps*
Mouse, southern California meadow	*Microtus californicus sanctidiegi*
Mouse, southern parasitic	*Peromyscus californicus insignis*

Common Name	*Scientific Name*
Mouse, spiny pocket	*Perognathus spinatus*
Mouse, Tejon pocket	*Perognathus l. longimembris*
Mouse, Townsend meadow	*Microtus townsendii*
Opossum, Florida	*Didelphis virginiana pigra*
Oven-bird	*Seiurus aurocapillus*
Owl, burrowing	*Speotyto cunicularia hypogaea*
Peccary, collared	*Pecari a. angulatus*
Pika, or cony	*Ochotona* sp.
Pika, Rocky Mountain	*Ochotona p. princeps*
Pika, Taylor	*Ochotona schisticeps taylori*
Pocket gopher	*Thomomys talpoides*
Pocket gopher, brown	*Thomomys f. fuscus*
Pocket gopher, Columbia	*Thomomys columbianus*
Pocket gopher, Illinois	*Geomys illinoensis*
Pocket gopher, Nevada	*Thomomys townsendii nevadensis*
Pocket gopher, prairie	*Thomomys fuscus rufescens*
Pocket gopher, Shaw	*Geomys bursarius*
Pocket gopher, southern	*Geomys floridanus austrinus*
Porcupine, yellow-haired	*Erethizon e. epixanthum*
Prairie dog	*Cynomys* spp.
Pyrrhuloxia (gray grosbeak)	*Pyrrhuloxia sinuata*
Quail, bobwhite	*Colinus virginianus*
Quail, California valley	*Lophortyx californica vallicolla*
Rabbit—cottontail, Black Hills	*Sylvilagus nuttalli grangeri*
Rabbit—cottontail, eastern	*Sylvilagus floridanus mallurus*
Rabbit—cottontail, New England	*Sylvilagus transitionalis*
Rabbit—cottontail, Rocky Mountain	*Sylvilagus nuttalli pinetis*
Rabbit—jack, antelope	*Lepus californicus alleni*
Rabbit—jack, black-tailed	*Lepus californicus*
Rabbit—jack, California	*Lepus c. californicus*
Rabbit—jack, Carolina marsh	*Sylvilagus p. palustris*
Rabbit—jack, Colorado desert	*Lepus californicus deserticola*
Rabbit—jack, Great Plains	*Lepus californicus melanotis*
Rabbit—jack, Florida marsh	*Sylvilagus palustris paludicola*
Rabbit—jack, Idaho pygmy	*Brachylagus idahoensis*
Rabbit—jack, Rocky Mountain snowshoe	*Lepus b. bairdi*
Rabbit—jack, snowshoe	*Lepus* sp.
Rabbit—jack, Washington	*Lepus californicus walla walla*
Rabbit—jack, white-tailed	*Lepus townsendi campanius*
Raccoon, Florida	*Procyon lotor elucus*
Raccoon, Hilton Head Island	*Procyon lotor solutus*
Rat, cotton	*Sigmodon hispidus*
Rat, eastern cotton	*Sigmodon h. hispidus*
Rat, domestic	*Rattus* spp.
Rat, Mohave kangaroo	*Dipodomys mohavensis*

Common Name	*Scientific Name*
Rat, Norway	*Rattus norvegicus*
Rat, Richardson's kangaroo	*Dipodomys ordii richardsoni*
Rat, rice	*Oryzomys palustris*
Rat, roof	*Rattus alexandrinus*
Rattlesnake, diamond	*Crotalus adamanteus*
Robin, western	*Planesticus migratorius propinquus*
Rock squirrel	*Otospermophilus* sp.
Sheep, mountain	*Ovis canadensis*
Shrew, Olympic	*Sorex setosus*
Shrew, short-tailed	*Blarina brevicauda*
Shrew, Trowbridge	*Sorex t. trowbridgii*
Shrew, wandering	*Sorex v. vagrans*
Shrike	*Lanius* sp.
Skink, red-headed	*Eumeces fasciatus*
Skunk, Florida	*Mephitis elongata*
Skunk, long-tailed Texas	*Mephitis mesomelas varians*
Skunk, Texas hog-nosed	*Conepatus leuconotus texensis*
Sparrow, Bachman's	*Aimophila aestivalis bachmani*
Sparrow, chipping	*Spizella p. passerina*
Sparrow, field	*Spizella p. pusilla*
Sparrow, Florida grasshopper	*Ammodramus savannarum floridanus*
Sparrow, fox	*Passerella iliaca*
Sparrow, golden-crowned	*Zonotrichia coronata*
Sparrow, Kodiak fox	*Passerella iliaca insularis*
Sparrow, Nuttall's song	*Melospiza m. melodia*
Sparrow, rusty song	*Melospiza melodia morphna*
Sparrow, Savannah	*Passerculus sandwichensis*
Sparrow, swamp	*Melospiza georgiana*
Sparrow, Wakulla seaside	*Ammospiza maritima juncicola*
Sparrow, white-crowned	*Zonotrichia l. leucophrys*
Sparrow, white-throated	*Zonotrichia albicollis*
Sparrow, Valdez fox	*Passerella iliaca sinuosa*
Squirrel, Cascades chickaree	*Sciurus douglasii cascadensis*
Squirrel, Douglas chickaree	*Sciurus douglasii mollipilosus*
Squirrel, fox	*Sciurus niger*
Squirrel, gray	*Sciurus carolinensis*
Squirrel, red	*Sciurus hudsonicus*
Squirrel, Richardson red	*Sciurus hudsonicus richardsoni*
Squirrel, rock	*Otospermophilus grammurus*
Squirrel, southern fox	*Sciurus n. niger*
Squirrel, southern gray	*Sciurus c. carolinensis*
Squirrel, western	*Sciurus griseus*
Squirrel, western fox	*Sciurus niger rufiventris*
Starling	*Sternus v. vulgaris*
Swallow, violet-green	*Tachycineta thalassina lepida*
Thrasher, brown	*Toxostoma rufum*

Common Name	Scientific Name
Thrush, hermit	*Hylocichla guttata*
Thrush, wood	*Hylocichla mustelina*
Tortoise, gopher	*Gopherus polyphemus*
Towhee, red-eyed	*Pipilo e. erythrophthalmus*
Towhee, white-eyed	*Pipilo erythrophthalmus alleni*
Vulture, turkey	*Cathartes aura septentrionalis*
Vulture, black	*Coragyps a. atratus*
Warbler, palm	*Dendroica palmarum*
Waxwing, Bohemian	*Bombycilla garrula pallidiceps*
Waxwing, cedar	*Bombycilla cedrorum*
Weasel	*Mustela* sp.
Weasel, New York	*Mustela n. noveboracensis*
Wolf, red	*Canis rufus*
Wolf, timber	*Canis gigas*
Woodchuck, pallid yellow-bellied	*Marmota flaviventris avara*
Woodchuck, southern	*Marmota m. monax*
Woodchuck, yellow-bellied	*Marmota f. flaviventris*
Woodpecker, red-bellied	*Centurus carolinus*
Wood rat, Baird's	*Neotoma micropus*
Wood rat, bushy-tailed	*Neotoma cinerea* subsp.
Wood rat, Colorado bushy-tailed	*Neotoma cinerea orolestes*
Wood rat, Florida	*Neotoma f. floridana*
Wood rat, large-eared	*Neotoma fuscipes macrotus*
Wood rat, Streator	*Neotoma fuscipes streatori*
Wood rat, western bushy-tailed	*Neotoma cinerea occidentalis*
Wren, Carolina	*Thryothorus l. ludovicianus*
Wren, Florida	*Thryothorus ludovicianus mamensis*
Wren, short-billed marsh	*Cistothorus stellaris*
Yellowthroat, Florida	*Geothlypis trichas ignota*
Yellowthroat, Maryland	*Geothlypis t. trichas*

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NEW MOSQUITO HOSTS FOR *PLASMODIUM GALLINACEUM*[1]

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Mosquito species previously reported to be susceptible to *Plasmodium gallinaceum* include 13 species of *Aëdes,* 5 species of *Armigeres* and 2 species of *Culex* (Brumpt 1936, Roubaud, Colas-Belcour and Mathis 1939, Vargas and Beltran 1941, Russell and Mohan 1942, Russell and Menon 1942). These records include only 3 species indigenous to North America, i.e., *Aëdes vexans* Meigen, *Aëdes aegypti* Linnaeus and *Culex quinquefasciatus* Say.

This report includes the results of observations on 2 American species that have and 7 that have not been previously studied. The mosquitoes were either reared from larvae or captured in the field as adults. They were allowed to feed on an infected chicken and were kept at 28° C. From 3 to 9 days later most of them were dissected and examined for oöcysts. A few were examined for sporozoites and oöcysts after 9 to 21 days.

As may be seen in Table 1, oöcysts were observed in *Aëdes campestris* Dyar and

TABLE 1.—*Susceptibility of various species of mosquitoes to infection with* Plasmodium gallinaceum

Species	Source	No. dissected*	No. infected	No. of oöcysts found
Fed on chickens with *Plasmodium gallinaceum*				
Aëdes campestris	Reared from larvae	16	15	130 (mean)
A. stimulans	Wild caught adults	10	6	2, 30, 120, 130
A. triseriatus	Reared from larvae	12	5	1, 25, 32
A. trivittatus	Wild caught adults	7	4	1, 3, 16, 52
A. vexans	Wild caught adults	21	20	607 (mean)
Culex pipiens	Reared from larvae	120	0	
C. salinarius	Reared from larvae	22	3	1, 2, 8
Mansonia perturbans	Wild caught adults	1	1	10
Theobaldia inornata	Reared from larvae	22	1	67
Not fed on chickens infected with *Plasmodium gallinaceum*				
A. stimulans	Wild caught adults	14	0	
A. trivittatus	Wild caught adults	5	0	
A. vexans	Wild caught adults	10	0	

*The majority of the mosquitoes were dissected 3 to 9 days after feeding. Four *A. campestris*, 2 *A. stimulans* and 2 *A. triseriatus* were dissected 9 to 21 days after feeding. Since the oöcysts of these mosquitoes had already ruptured, accurate counts could not be made, but sporozoites were found in the salivary glands of all of them.

Knab, *Aëdes stimulans* Walker, *Aëdes triseriatus* Say, *Aëdes trivittatus* Coquillet, *A. vexans, Culex salinarius* Coquillet, *Mansonia perturbans* Walker and *Theobaldia inornata* Williston. Sporozoites were observed in the salivary glands of 4 *A. campestris* after 9 to 14 days; in 2 *A. stimulans* after 12 days and in 2 *A. triseriatus* after 21 days. With the exception of *A. vexans,* these species are new hosts for *P. gallinaceum.* The results are in accord with the experiments of other workers in that no species of *Aëdes* has been found that is insusceptible to *P. gallinaceum.*

As previously reported by Brumpt, *Culex pipiens* Linnaeus seems to be in-

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susceptible to infection with *P. gallinaceum* inasmuch as none of 120 mosquitoes became infected. Three of 22 *C. salinarius* became infected.

To rule out the possibility that the wild-caught adults had acquired infections in nature, 10 *A. vexans,* 5 *A. trivittatus* and 14 *A. stimulans,* captured at the same time as were the individuals used for experimental feeding, were dissected without being given an experimental blood meal. No oöcysts were found, as shown in Table 1. Further evidence that the infections were not acquired previous to the experimental blood meal is furnished by the fact that the oöcysts were of approximately the same size and stage of development as oöcysts of the same age in *A. aegypti.*

The values shown in the table for mean numbers of oöcysts should not be taken to indicate comparative susceptibility of the species since the mosquitoes were fed on different chickens. The intensity of the infection in *A. vexans,* however, suggests that this species is particularly susceptible.

Infections were produced in chickens by intramuscular injections of ground salivary glands from *A. campestris* and *A. stimulans.*

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A NEW SPECIES OF THE ACANTHOCEPHALAN GENUS *ILLIOSENTIS* (RHADINORHYNCHIDAE)*

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Van Cleave and Lincicome (1939) described *Illiosentis furcatus* as type of a previously unknown genus of the acanthocephalan family RHADINORHYNCHIDAE. The host of this species is *Menticirrhus americanus,* a marine fish of the Gulf of Mexico, belonging to the family SCIAENIDAE, the Croakers. *M. americanus* is the only host species and the Gulf Coast the only region from which *I. furcatus* has been recorded.

In a survey of the worm parasites of the fishes caught by fishermen on the Scripps Institution pier during the spring of 1940, three species of croakers or roncadors (family SCIAENIDAE) were studied intensively. One of these, *Menticirrhus undulatus* (Girard) (locally called the California corbina) was found to be especially heavily infected by a species of the genus *Illiosentis.* Fourteen of 16 individuals carried this worm in numbers ranging from a few to about 200 individuals. The same species of worm was found less frequently and in lighter infections in *Roncador stearnsi* (Steindachner) (the spotfin croaker) and in *Umbrina roncador* Jordan and Gilbert (the yellowfin croaker). Both of these species of fish were caught by line fishermen on the same surf-swept beaches from which the heavily infected *Menticirrhus* were taken. Only 2 of the 4 *Roncador stearnsi* were infected by *Illiosentis* and in these, 4 was the maximum number of worms found in any individual. In 9 specimens of *Umbrina roncador* examined, a single worm was found. In a rather extensive survey of parasites of other fishes in the same region, no other species of fish were encountered as host for *Illiosentis.*

A study of stained permanent mounts demonstrated that the *Illiosentis* from La Jolla is specifically distinct from the only previously known member of the genus. The new species is here described as *Illiosentis cetratus.*

Illiosentis cetratus n. sp.
(Figs. 1–3)

With all of the essential characteristics of the genus *Illiosentis* as enumerated by Van Cleave and Lincicome (1939: 414). Body elongate, flattened in living, turgidly rounded in preserved specimens; preserved females 20 to 37 mm long and 0.55 to 0.77 mm in maximum diameter; males 15 to 27 mm long by 0.44 to 0.66 mm in diameter. The posterior extremity of the body of females has the distinctive cleft in the region of the genital pore as described for *I. furcatus* and internally bears a conspicuous fan-shaped muscular organ bordering the inner margin of the genital cleft as in the genotype. Although on some females there is a pair of lateral body folds adjacent to the pore, a careful examination of several dozen females failed to reveal any papillae or spines such as are distinctive for *I. furcatus.* The observed lateral folds are somewhat similar to those figured for the genital area of *Tegorhynchus* (Van Cleave, 1921). Since the cuticular spines on the genital extremity of the female were cited in the original characterization of the genus *Illiosentis,* their absence in *I. cetratus* stands as evidence that this character has only specific

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value and should be eliminated from the generic diagnosis. Body spines numerous, restricted to a single uninterrupted zone at the anterior end of the body; commonly 38 to 42 μ in length.

Proboscis (Figs. 2 and 3) elongate, clavate, unusually somewhat larger in the female than in the male; 1.6 to 2 mm in length by 0.245 to 0.385 mm in diameter. Proboscis hooks quin-

EXPLANATION OF PLATE

Illiosentis cetratus n. sp.

FIG. 1. Posterior extremity of holotype male (VC 3677.4) showing extruded copulatory bursa. The posterior end of the hind testis is shown at the upper end of the drawing, followed by group of eight intertwined cement glands. Reference line is 0.5 mm long.

FIGS. 2 and 3. Proboscis and a small portion of body proper showing form of proboscis, size and arrangement of hooks and of body spines. A sensory papilla shows in fig. 2 near the base of the eleventh hook from the posterior end of the proboscis. Both figures are of paratype females. Reference lines are 0.1 mm long.

cunxial in arrangement, usually in 16 longitudinal rows with from 19 to 24 (most frequently 20 to 22) hooks in each longitudinal row. A pair of small, rounded, lateral papillae near base

of proboscis, at level of from 8 to 14 hooks from posterior extremity of proboscis. Hooks in basal circle often reaching 70 to 84 μ on ventral surface, but usually less than 70 μ on dorsal. On remainder of proboscis hooks are of somewhat variable length, ranging from 42 to 91 μ near the middle but of more slender form near the anterior tip where they are commonly 49 to 84 μ long.

Embryos within the body of gravid females, about 58 to 72 μ long by 8 to 12μ in diameter.

In all other anatomical features, including arrangement of the genital organs of the male (Fig. 1), the anatomical features of *I. cetratus* are essentially like those described for *I. furcatus.*

Holotype male (VC 3677.4); allotype female (VC 3680.2) and series of paratypes of both sexes in the collection of H. J. Van Cleave, Urbana, Illinois.

Hosts: mature worms in intestine of *Menticirrhus undulatus* (Girard) and less frequently in *Roncador stearnsi* (Steindachner) and *Umbrina roncador* Jordan and Gilbert at La Jolla, California. Alternate hosts and developmental stages unknown.

I. cetratus differs from *I. furcatus,* the only other species known for the genus *Illiosentis,* most conspicuously in the number and arrangement of the proboscis hooks. The new species has 16 longitudinal rows of 19 to 24 hooks each while the proboscis of *I. furcatus* bears 14 longitudinal rows of 26 to 33 hooks each. Geographical distribution of the two species does not overlap. The new species seems to be restricted to the Pacific coast of southern California while *I. furcatus* has been found only in the Gulf of Mexico.

Acanthocephala are not abundantly represented in the marine fishes of the La Jolla region. During April and May of 1940, the writer conducted a survey of the worm parasites in the marine fishes of that region in which 34 species of fish and a total of more than 190 individuals were examined. Many of the species were represented by only one or a few autopsies, but in the entire survey the only mature acanthocephalans encountered were the specimens of *Illiosentis cetratus* described in this paper.

As was mentioned in the original article describing *I. furcatus,* there have been two earlier references in the literature (Linton, 1905: 398 and Meyer, 1933: 347) to a rhadinorhynchid in *Menticirrhus americanus.* Both of these give the identification, at least tentatively, as *Rhadinorhynchus pristis.* The earlier of these records cites Beaufort, N. C., as the locality. The other reference is less definite, and the identity of the species is questioned by Meyer. The reference in Meyer's monograph is given in the section listing all the species of ACANTHOCEPHALA known to occur in the various species of fish, but in the taxonomic section of the text (pp. 47–56) there is no mention of *Menticirrhus* as host for any species of *Rhadinorhynchus.* The writer has been unable to secure the original material on which these two records are based and so can neither verify nor correct the identifications. The extensive studies of Linton on parasites of fishes of the Atlantic coast have never recorded an acanthocephalan that could be recognized as an *Illiosentis.* Nor has this genus been represented in numerous collections from marine fishes of the Atlantic coast that have come to the writer for study. However, *Rhadinorhynchus tenuicornis* has been often encountered in such collections although it has never been found as yet in *Menticirrhus* of that region.

In spite of the fact that *R. pristis* has been nominally recorded from fishes of the Atlantic coast of North America, there is no recent authoritative verification of the earlier records. Linton (1892) recorded specimens which he deemed to be *Echinorhynchus* (= *Rhadinorhynchus*) *pristis* and in the same publication mentioned a variant to which he applied the name *E. pristis tenuicornis.* In 1918, the present writer showed that the former of these is a distinct and previously unnamed species

to which the name *Rhadinorhynchus ornatus* was applied. In the same revision, the supposed variety of this form was more fully described and was elevated to the status of a distinct species under the name *Rhadinorhynchus tenuicornis*. Following an error in judgment of the author, who referred to *R. tenuicornis* as a new species, several subsequent writers have credited this name to Van Cleave. Since the name was applied as a subspecific name by Linton (1892) in its elevation to specific status the name of the original author should be retained, and the name should be cited *Rhadinorhynchus tenuicornis* (Linton, 1892) Van Cleave, 1918.

An appreciation of the specific distinctness of the two forms which Linton and others erroneously considered as *R. pristis* was strengthened when Chandler (1934) pointed out fundamental morphological differences between them. These differences led him to recognize the genus *Nipporhynchus* which now (Van Cleave and Lincicome, 1940: 179) accommodates *ornatus* while *tenuicornis* remains within the genus *Rhadinorhynchus*. Within recent years numerous collections of Acanthocephala from the Atlantic and from the Gulf of Mexico have been examined critically without discovering *R. pristis* in any of them.

In a preliminary abstract (Van Cleave, 1940) the author emphasized the differences encountered in the parasites of closely related hosts of ACANTHOCEPHALA. The species of the families Rhadinorhynchidae and Gorgorhynchidae offer many interesting problems in the analysis of host-parasite interrelationships. Some species of Acanthocephala with broad geographical range are absent from definite areas within their range, in part at least [as suggested by Chandler (1935: 123) for *R. tenuicornis*] because of the local nature of the distribution of essential intermediate hosts. On the other hand, within a given area where both definitive and intermediate hosts are present, differences in feeding habits of the fish host may be the basis for explanation of differences in incidence of parasitism. This seems the logical explanation for the heavy and general infection by *I. cetratus* in *Menticirrhus undulatus* in an area where *Umbrina roncador* is virtually free from this parasite.

The occurrence of two distinct but closely related species of *Illiosentis* in two different species of *Menticirrhus,* which are separated by natural barriers, offers the suggestion that speciation within the genus *Illiosentis* has accompanied speciation within the host genus *Menticirrhus*.

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INFLUENCE OF LARVAL TREMATODE INFECTIONS IN SNAILS ON THEIR SECOND INTERMEDIATE HOST RELATIONS TO THE STRIGEID TREMATODE, *COTYLURUS FLABELLIFORMIS* (FAUST, 1917)[1]

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INTRODUCTION

The present paper will include the data we have accumulated during our studies at the University of Michigan Biological Station on the effect of infections with larval trematodes in lymnaeid snails on their second intermediate host relations to the strigeid trematode, *Cotylurus flabelliformis*. Three of the papers of this series have already dealt with certain aspects of this phase of the subject (Winfield, 1932; Nolf and Cort, 1933; Cort, Olivier and Brackett, 1941). In the four papers of this series already published an account has been given of the life cycle of this trematode, the development of its metacercariae, and the methods used in our studies, which need not be repeated here. For the purpose of comparing the extent of development, the metacercariae counted in our experiments were frequently classified into three arbitrary groups according to the stage of development, viz., (1) "developing" (all stages up to the largest and those beginning to reorganize), (2) "pre-cysts" (those with a distinct hind-body but without a cyst wall, and (3) "cysts" (those that had completed their development and were surrounded by a cyst wall). For the convenience of the reader, the names of the trematode species mentioned in this paper and the pertinent literature on their larval stages are listed in Table 1.

It has been shown in a recently published paper (Cort, Brackett and Olivier, 1944) that the metacercariae of *C. flabelliformis* can complete their development in several different species of lymnaeid snails. When such snails do not harbor the germinal sacs of trematodes, the metacercariae are localized in the hermaphroditic gland which lies imbedded in the digestive gland. In this location they go through their profound metamorphosis from the cercarial body to the encysted metacercarial stage (tetracotyle) in close contact with the host's tissues and feed directly on its substance. When, however, sporocysts or rediae of trematode parasites are present in the digestive gland of the snails, the metacercariae of *C. flabelliformis* develop as hyperparasites inside them. In this location they are cut off completely from the tissues of the snail and must feed on the material absorbed by the germinal sacs and elaborated by them for the nourishment of their developing progeny. Whenever the cercariae of *C. flabelliformis* are able to get into sporocysts or rediae, the metacer-

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cariae almost always develop rapidly to the encysted stage. In fact, as hyperparasites in these germinal sacs they develop more rapidly than in their normal position in the hermaphroditic gland of uninfected hosts.

The presence of larval trematode parasites influences in at least three different ways the ability of the cercariae of *C. flabelliformis* to establish themselves and to develop to the metacercarial stage in snail second intermediate hosts. In the first place, the presence of the sporocysts and developing cercariae of *C. flabelliformis* almost entirely prevents the penetration of the cercariae of this species. In other words, a snail that is serving as an intermediate host of this species cannot be effectively utilized as a second intermediate host. In the second place, the presence of infections with certain other species of larval trematodes partly or, in some cases, almost entirely prevents the use of such infected snails as second intermediate hosts for *C. flabelliformis*. Finally, larval trematode parasites in snails that are not suitable second intermediate hosts for this strigeid may permit its metacercariae to develop, or in partially abnormal hosts they may increase the susceptibility.

TABLE 1.—*List of scientific names and pertinent references for the species of trematodes mentioned in this paper*

Trematode species	Group	References on larval stages
Cotylurus flabelliformis (Faust, 1917)	Strigeid	Cort and Brooks, 1928; Olivier and Cort, 1941a; Van Haitsma, 1931a
Diplostomum flexicaudum (Cort and Brooks, 1928)	"	Cort and Brooks, 1928; Van Haitsma, 1931b
Cercaria emarginatae Cort, 1917	"	Cort, 1917; Olivier and Cort, 1941b
Cercaria yogena Cort and Brackett, 1937	"	Cort and Brackett, 1937b; Cort, McMullen, and Brackett, 1937
Cercaria laruei Cort and Brooks, 1928	"	Cort and Brooks, 1928; Cort, McMullen, and Brackett, 1937
Cercaria macradena Cort and Brackett, 1938		Cort and Brackett, 1938
Schistosomatium douthitti (Cort, 1914)	Schistosome	Price, 1931
Cercaria stagnicolae Talbot, 1936	"	Talbot, 1936; Cort, McMullen, and Brackett, 1937
Plagiorchis muris Tanabe, 1922	Plagiorchiid	McMullen, 1937
Plagiorchis proximus Barker, 1915	"	McMullen, 1937
Plagiorchis micracanthos Macy, 1931	"	McMullen, 1937
Cercaria talboti McMullen, 1938	"	McMullen, 1938b
Echinostomum revolutum (Froelich, 1802)	Echinostome	Beaver, 1937

INFLUENCE OF INFECTIONS WITH THE SPOROCYSTS OF *C. flabelliformis* IN THE VARIETIES OF *Lymnaea stagnalis* AND *Stagnicola emarginata*

It was first shown by Winfield (1932) and later confirmed by Nolf and Cort (1933) that the presence of the daughter sporocysts and developing cercariae of *C. flabelliformis* in snails of the varieties of *L. stagnalis*[5] prevented almost all of the cercariae of this same trematode from penetrating even when such infected snails were exposed to very large numbers. The few cercariae that were able to penetrate into the infected snails, however, entered the daughter sporocysts and developed normally. We have obtained evidence that this same relation also holds for *Stagnicola emarginata angulata* (Sowerby). Adults of this snail variety from a beach near

[5] Two varieties of this species of snail are present in the Douglas Lake region, *L. s. appressa* Say and *L. s. perampla* Walker. They are difficult to distinguish and are intermingled in the area. Both of these varieties were used in the experiments, and no attempt was made to determine to which of them each individual belonged.

Phragmites Flats on Douglas Lake examined during the summer of 1933, harbored unusually large numbers of the metacercariae of *C. flabelliformis*. As shown in Table 2, 27 individuals not infected with larval trematodes contained numbers of metacercariae ranging from 285 to 2921 with an average of 1531. Contrasted with these large numbers, the four snails of this series (Table 2) infected with the sporocysts of *C. flabelliformis* had numbers of metacercariae ranging from 1 to 40 with an average of 21. Earlier in the summer six other individuals of *S. e. angulata* infected with the sporocysts of *C. flabelliformis* were examined from this same beach. They contained numbers of metacercariae varying from 0 to 48 with an average of 15. There is no reason to believe that these 10 snails infected with the sporocysts of *C. flabelliformis* could have in any way escaped the long continued exposure to the cercariae of this trematode which had resulted in such large numbers of metacercariae in other snails on this beach. It is evident, therefore, that in *S. e. angulata,* as well as in the varieties of *L. stagnalis,* the presence of the sporocysts and developing cercariae of *C. flabelliformis* protects the snails from the penetration of the cercariae of this same species.

INFLUENCE OF LARVAL TREMATODE PARASITES, OTHER THAN *C. flabelliformis,* IN NORMAL SECOND INTERMEDIATE HOSTS

Nolf and Cort (1933) reported a few experiments on the influence of infections with larval trematodes, other than *C. flabelliformis,* on the development of the metacercariae of *C. flabelliformis* in normal second intermediate hosts. Since this preliminary work we have been able to add a considerable amount of information on this phase of the problem from the examination of natural infections and from experiments, which will be presented below.

TABLE 2.—*Summary of counts of the metacercariae of* C. flabelliformis *from natural infections in a collection of* S. emarginata angulata *made July 26, 1933, from the "Phragmites Flats Area" on Douglas Lake. The examinations were made from August 1 to 22. The infection came from cercariae that had developed in* S. e. angulata

No. of snails	Larvae trematode infections	Metacercariae of *C. flabelliformis*		
		Range	Average	Per cent encysted
27	Uninfected	285–2921	1531	49
4	*C. flabelliformis*	1–40	21	96
7	*C. yogena*	755–2072	1292	62
6	*C. laruei*	419–2425	1592	42
2	*C. emarginatae*	2296, 2535	———	85
4	*P. proximus*	554–1583	1202	80
27	*D. flexicaudum*	6–2243	963	57
6	*P. muris*	1–87	23	86
6	*E. revolutum*	1–150	38	94

Data from examinations of natural infections in S. e. angulata.—Evidence on the influence of the presence of the germinal sacs of other trematodes on the second intermediate host relations of *S. e. angulata* to *C. flabelliformis* came from the series of examinations for natural infections with the metacercariae from the "Phragmites Flats area" already mentioned in this paper and discussed in a previous paper (Cort, Brackett and Olivier, 1944). It was brought out in that paper that the snails on this beach had been exposed for a long period of time to constant infection with the cercariae of *C. flabelliformis* that had developed in the same variety of snail. A summary of the results for the snails examined from this beach is given in Table 2. It can be seen that they were infected with several different species of larval trematodes.

The evidence seemed clear that all of them had had the same type of exposure to the cercariae of *C. flabelliformis* and that any consistent differences in the numbers of metacercariae that they harbored could only be explained on the basis of their larval trematode infections.

It can be seen from Table 2 that the snails of this series of examinations infected with three of the strigeid species (*C. yogena, C. laruei,* and *C. emarginatae* and with one of the plagiorchiids (*P. proximus*) had numbers of metacercariae comparable to those in the uninfected group. The 27 snails listed in Table 2 that were infected with the sporocysts of *D. flexicaudum* had an average number of metacercariae about two-thirds as great as that of the uninfected group. Also, seven of them had counts below the lowest of that group, the two smallest being 6 and 18 respectively. Finally, the numbers of metacercariae found in the six snails infected with the sporocysts of the other plagiorchiid, *P. muris,* and those in the six infected with the rediae of an echinostome, *E. revolutum,* were very small. In fact, the numbers of metacercariae in the snails parasitized by these two species were similar to those in the snails infected with *C. flabelliformis.*

Experimental studies with S. e. angulata.[6]—Stimulated by the results of the series of examinations just discussed, we carried out several experiments in which specimens of *S. e. angulata* both unparasitized and parasitized with the germinal sacs of larval trematodes, were exposed to the cercariae of *C. flabelliformis* from *S. e. angulata* and *S. e. canadensis* (Sowerby). A summary of the results of these experiments is given in Table 3. The small numbers of snails in four of these experiments [6 (1933); 15 (1933); 18 (1933); 14 (1935)] that were infected with two of the strigeids, *C. yogena* and *C. laruei,* and with one of the plagiorchiids, *P. proximus,* had numbers of metacercariae of *C. flabelliformis* close to the range found in the uninfected groups. The results of the counts for the snails infected with the sporocysts of *D. flexicaudum* were very striking and consistent since in every case the numbers of the metacercariae were very small. In four of the experiments of Table 3 [6 (1933); 15 (1933); 12 (1935); 15 (1935)] there were in all 75 adults of *S. e. angulata* infected with the sporocysts of *D. flexicaudum,* which had been given exposure to the cercariae of *C. flabelliformis* that produced in the uninfected snails of the same experiments average numbers of metacercariae varying from 42 to 374. Of these 75 snails, 57 had no metacercariae, and only 9 of the others had more than 10. It seems evident, therefore, that in experimental infections of this grade, the presence of the sporocysts of *D. flexicaudum* greatly reduced the numbers of the metacercariae that developed. The few that were found were inside the sporocysts and appeared to be developing normally. In the snails infected with *P. muris,* the numbers of metacercariae were also very small and a large proportion of the snails were negative (Table 3). Of 59 snails in three experiments harboring the sporocysts of this trematode, [18 (1933); 14 (1935); 20 (1938)] 35 were negative for metacercariae and only eleven had more than ten. In addition, the counts in Table 3 show that only very small numbers of metacercariae developed in snails infected with the germinal sacs of another plagiorchiid, *P. micracanthos* [18 (1933)], an echinostome, *E. revolutum* [14 (1935)], and a schistosome, *C. stagnicolae* [14 (1935)].

[6] To make it easier for the reader to follow the rather complicated relations of the different species of larval trematode parasites to the development of the metacercariae of *C. flabelliformis,* a very condensed summary for this and the later series of experiments is given in Table 7.

Experiment with Stagnicola palustris elodes (*Say*).—Only one of our experiments [4 1937)] included specimens of *S. p. elodes* infected with the germinal sacs of larval trematodes (Table 4). The uninfected snails and those parasitized with larval trematodes used in this experiment came from two different collections. As shown in the description of Table 4 both collections had some naturally acquired

TABLE 3.—A summary of the counts of the metacercariae of *C. flabelliformis* in experiments in which uninfected and infected specimens of *S. e. angulata* were exposed to the cercariae of *C. flabelliformis* from *S. e. angulata* [6 (1933) ; 15 (1933) ; 18 (1933) ; 20 (1938)] and from *S. e. canadensis* (Sowerby) [12 (1935) ; 15 (1935) ; 14 (1935)]. All the experimental snails were adults except in Experiment 20 (1938).

Control examinations were made as follows for previously acquired natural infections with metacercariae of *C. flabelliformis* of snails from the same collections as these used in the experiments :

12 (1935) : 12 *S. e. angulata,* negative
15 (1935) : 18 *S. e. angulata,* negative
14 (1935) : 16 *S. e. angulata,* negative
20 (1938) : 25 *S. e. canadensis,* negative

No control examinations were made for the experiments performed in 1933 [6 (1933) ; 15 (1933) ; 18 (1933)]. All the experimental snails used in these three experiments had been naturally infected with small numbers of metacercariae. This was shown by the fact that a few "cysts" were present in them at the time of examination which could not have developed from experimentally introduced cercariae since the time from first exposure to examination was from 9 to 12 days in these experiments. For this reason these cysts are not enumerated in Table 3.

Exper. No.	Days from infection to examination	Larval trematode infections in experimental snails	Data from metacercarial counts			
			No. of snails	No. pos. for metacercariae	Range in numbers of metacercariae	Av. no.
6 (1933)	10	Uninfected	16	16	14–93	42
		C. yogena	2	2	10 & 72	—
		D. flexicaudum	29	2	3 & 3	—
15 (1933)	8–9	Uninfected	5	5	54–705	272
		C. yogena	1	1	130	—
		C. laruei	2	2	17 & 245	—
		D. flexicaudum	20	7	0–81	10
12 (1935)	20–24	Uninfected	6	6	22–443	278
		D. flexicaudum	21	10	0–31	4
15 (1935)	0–12	Uninfected	19	19	81–785	374
		D. flexicaudum	5	3	0–85	29
18 (1933)	8–12	Uninfected	29	28	0–1039	138
		C. laruei	2	2	25 & 68	—
		P. proximus	3	3	2, 29 & 88	—
		P. micracanthos	5	2	0–10	3
		P. muris	22	9	0–90	9
14 (1935)	8–18	Uninfected	15	14	0–464	199
		P. proximus	5	5	56–259	134
		P. muris	30	14	0–40	7
		E. revolutum	8	5	0–11	3
		C. stagnicolae	5	3	0–27	6
20 (1938)	35–36	Uninfected (juv.)	58	35	0–131	25
		P. muris	7	1	2	—

metacercariae of *C. flabelliformis,* which were more numerous in the group from which the parasitized snails were taken. The parasitized group of experimental snails harbored the germinal sacs of three different trematode species, viz., a plagiorchiid, *C. talboti,* a large echinostome that was not identified, and a strigeid, *C. macradena.* It can be seen from Table 4 that the metacercarial counts for the snails infected with *C. talboti* and the large echinostome were only about one-fourth the size of those of the uninfected group, while those for two snails infected with *C. macradena* were within the range of those for the uninfected group. In interpreting

the counts of metacercariae in this experiment, it must be remembered that all the snails used had had a slight previous exposure to infection. However, the fact that the snails infected with larval trematodes came from the collection that had the larger numbers of naturally acquired metacercariae makes the small numbers of metacercariae found in the experimental snails infected with *C. talboti* and the large echinostome even more significant. It can, therefore, be suggested that the presence of these two larval trematode species in the snails was responsible for the small numbers of metacercariae of *C. flabelliformis* that were able to establish themselves.

TABLE 4.—A summary of the counts of the metacercariae of *C. flabelliformis* in an experiment [4 (1937)] in which uninfected and infected adults of *S. p. elodes* were exposed to cercariae of *C. flabelliformis* from *L. stagnalis*.

Control examinations were made as follows for previously acquired natural infections with metacercariae of *C. flabelliformis* of snails from the same collections as those used in the experiments:

1. Collection from which uninfected experimental snails were taken: 20 snails, six positive with a total of 9 metacercariae.
2. Collection from which infected experimental snails were taken: 19 snails, 13 positive with a total of 119 metacercariae.

Exp. No.	Days from infection to exam.	Larval trematode infections in experimental snails	No. of snails	No. pos. for metacercariae	Data from metacercarial counts				
					Range in number	Av. no.	% "cysts"	% "pre-cysts"	% "developing"
4(1937)	19-22	Uninfected	33	33	6–108	43	66.5	19.5	14.0
	"	*C. talboti*	25	21	0–48	10	99.2	0.0	0.8
	"	Large echinostome	10	7	0–49	10	81.7	17.3	1.0
	"	*C. macradena*	2	2	51 & 66	—	100.0	0.0	0.0

INFLUENCE OF LARVAL TREMATODE PARASITES ON THE SUSCEPTIBILITY OF ABNORMAL SECOND INTERMEDIATE HOSTS

A large part of our experimental studies on this particular phase of the problem has already been published (Cort, Olivier and Brackett, 1941). It was reported in that paper that physid and planorbid snails are abnormal second intermediate hosts for the cercariae of *C. flabelliformis*. The cercariae penetrated into the snails belonging to these two families but almost no development took place unless they were infected with certain species of larval trematodes. In such parasitized snails the cercariae penetrated into the germinal sacs of the trematodes and developed, frequently in large numbers, as hyperparasites. In fact, the metacercariae completed their development under these conditions in a shorter time than in lymnaeid snails, not infected with larval trematodes, that were used in the experiments as normal second intermediate host controls.

In an earlier paper (Cort, Brackett and Olivier, 1944) it has been shown that *L. stagnalis* is almost a completely abnormal second intermediate host for the variety of *C. flabelliformis*, the cercariae of which develop in *S. emarginata*. Also, *S. emarginata*, especially in the juvenile stage, is abnormal in its second intermediate host rela-

tions to the variety of *C. flabelliformis* the cercariae of which develop in *L. stagnalis*. It seemed of interest, therefore, to determine whether the presence of the germinal sacs of larval trematodes would make these snails more susceptible to the metacercarial stages of the varieties of *C. flabelliformis* that do not develop normally in them.

Experiments with L. stagnalis *exposed to cercariae of* C. flabelliformis *from* S. emarginata.—The information on this relation in *L. stagnalis* is rather meager. In one of the experiments [5 (1936)] (not included in the tables of this paper) in which this host was exposed to cercariae of *C. flabelliformis* from *S. emarginata,* some of the experimental snails were infected with the sporocysts of *S. douthitti* and others with those of *D. flexicaudum*. The snails in this experiment were exposed to the cercariae from two infected specimens of *S. e. angulata* for a period of ten days. On examination over five weeks after the first exposure to the cercariae the nine snails without larval trematode parasites had numbers of metacercariae ranging from 0 to 300 with an average of 40, of which 77.9 per cent were "cysts," 6.6 per cent "pre-cysts," and 15.5 per cent developing. However, five of these nine snails were entirely negative for metacercariae, two had very small numbers (1 and 7) and only two had larger numbers (54 and 300). Only two of the five snails infected with the sporocysts of *S. douthitti* had metacercariae and then in only very small numbers (1 and 11). However, all the seven snails in this experiment infected with the sporocysts of *D. flexicaudum* harbored metacercariae varying in numbers from 6 to 141 with an average of 44, of which 45.9 per cent were "cysts," 28.7 per cent "pre-cysts," and 25.4 per cent "developing." It is not possible to be sure that there were not some naturally acquired metacercariae in the snails in this experiment because only two individuals of the same collections were examined for metacercariae. These two were negative. At any rate, it is perfectly evident that the presence of the sporocysts of *S. douthitti* in no way increased the susceptibility of the snails. On the other hand, the presence of the sporocysts of *D. flexicaudum* seemed to increase the susceptibility of the snails that harbored this trematode.

Experiments with juveniles of S. emarginata *exposed to the cercariae of* C. flabelliformis *from* L. stagnalis.—The experiments in which juveniles of *S. emarginata* were exposed to cercariae of *C. flabelliformis* from *L. stagnalis* [21 (1938); 1A and 1B (1941); 2 (1941)] gave clear-cut results (Table 5). In these experiments as shown in the table and discussed in the earlier paper (Cort, Brackett, and Olivier, 1944) there was almost no normal development of the metacercariae in the snails not parasitized with larval trematodes. These results were interpreted as indicating that the juveniles of *S. emarginata* are almost completely abnormal hosts for the variety of *C. flabelliformis,* the cercariae of which develop in *L. stagnalis*. The presence of the sporocysts of trematodes changed this relation completely. In the first experiment of Table 5 the six juveniles of *S. e. canadensis* infected with the sporocysts of *D. flexicaudum* had an average of 124 metacercariae almost all of which were encysted, while the 73 unparasitized snails had an average of only 23 metacercariae, hardly any of which had even started to develop. In experiment 1A (1941) the results are even more striking since none of the 26 uninfected juveniles of *S. e. angulata* had any metacercariae at all while the numbers in the five snails infected with the sporocysts of *P. muris* were almost as large as in the much larger uninfected adults of *S. p. elodes* that had had the same exposure to the cercariae. In experiment 1B (1941) the results are equally clear cut since only one of the 25 unin-

TABLE 5.—Metacercarial counts in experiments in which juveniles of *S. emarginata* were exposed to the cercariae of *C. flabelliformis* from *L. stagnalis*.

The following numbers of snails were examined from the same collections as those used in the experiments for previously acquired natural infections and all were negative for the metacercariae of *C. flabelliformis:* 21 (1938), 25; 1A and B (1941), 20; 2 (1941) at least 100.

Exp. No.	Days from infection to examination	Larval trematode infections in experimental snails	Data from metacercarial counts						
			No. of snails	No. pos. for metacercariae	Range in no.	Av. no.	% "cysts"	% "precysts"	% "developing"
21 (1938)	36–37	*S. e. canadensis* (juv.)—uninfected	73	47	0–184	23	....	...	99.0
	"	*S. e. canadensis* (juv.)—*D. flexicaudum*	6	5	0 271	124	99.0	...	....
1A (1941)	22	*S. p. elodes* (adult)—uninfected	4	4	14–127	49	64.9	35.1	0.0
	"	*S. e. angulata* (juv.)—uninfected	26	0	.....	0	....	...	....
	"	*S. e. angulata* (juv.)—*P. muris*	5	5	21–80	43	69.4	14.8	15.8
1B (1941)	29	*S. p. elodes* (adult)—uninfected	5	5	4–54	38	95.8	4.2	0.0
	"	*S. e. angulata* (juv.)—uninfected	25	1	6	...	....	...	....
	"	*S. e. angulata* (juv.)—*P. muris*	10	8	0–263	47	98.1	1.5	0.4
	"	*S. e. angulata* (juv.)—*D. flexicaudum*	5	5	4–36	20	100.0	0.0	0.0
2 (1941)	16–18	*B. megasoma* (adult)—uninfected	7	7	3–51	16	0.0	0.0	100.0
	"	*S. e. angulata* (juv.)—uninfected	23	18	0–48	18	0.0	0.0	100.0
	"	*S. e. angulata* (juv.)—*P. muris*	9	9	7–214	82	0.0	96.4	3.6
	"	*S. e. angulata* (juv.)—*P. proximus*	1	1	184	...	0.0	91.2	9.8
	"	*S. e. angulata* (juv.)—*D. flexicaudum*	2	2	48 & 398	...	0.0	76.0	24.0

fected juveniles had any metacercariae, and then a very small number, while the average for the 10 juveniles of *S. e. angulata* infected with the sporocysts of *P. muris* was considerably larger than for the adults of *S. p. elodes*. The 5 snails infected with the sporocysts of *D. flexicaudum* in this experiment had somewhat smaller numbers of metacercariae, all of which were encysted. Finally in experiment 2 (1941) the uninfected juveniles of *S. e. angulata* had an average of 18 metacercariae almost all of which had hardly started development at all, while the snails infected with the sporocysts of *P. muris, P. proximus* and *P. flexicaudum* had much larger numbers which were developing normally. Taken together the results of these four experiments clearly show that the presence of the germinal sacs of these trematodes in juveniles of *S. emarginata,* which when uninfected were almost completely abnormal second intermediate hosts for the cercariae of *C. flabelliformis* from *L. stagnalis,* permitted the normal development of considerable numbers of the metacercariae.

Experiments with adults of S. emarginata *exposed to the cercariae of* C. flabelliformis *from* L. stagnalis.—As suggested in the earlier paper (Cort, Brackett, and Olivier, 1944) and shown in Table 6, adults of *S. e. angulata,* when exposed to the cercariae of *C. flabelliformis* from *L. stagnalis* show less abnormality in their second intermediate host relations than juveniles of the same species, since frequently a considerable number of metacercariae developed normally in them. It was brought out, however, that the numbers of metacercariae that developed were considerably less than in adults of *S. emarginata* that were exposed to cercariae of *C. flabelliformis* from this same host (cf. Tables 3 and 6).

It was of interest, therefore, to see whether adults of *S. emarginata* that were infected with the germinal sacs of larval trematodes would take larger numbers of the metacercariae than the unparasitized snails of the same species when exposed to the cercariae of *C. flabelliformis* from *L. stagnalis.* Table 6 gives the metacercarial counts from the experiments of our series that give information on this point. It can be seen from this table that the adults of *S. e. angulata* in the experiments that harbored the sporocysts of three of the strigeid species (*C. emarginatae, C. yogena,* and *C. laruei* [13 (1935); 5B (1937); 5D (1937); 5E (1937)] had very much larger numbers of metacercariae than the unparasitized specimens of *S. e. angulata* in the same experiments. The number of snails infected with these three strigeids is rather small in any particular experiment but the differences are striking and consistent. In the four experiments taken together, the 17 snails infected with these three strigeids had numbers of metacercariae ranging from 11 to 467 with an average of 112; while the 33 unparasitized specimens of *S. e. angulata* in the same experiments had numbers ranging from 1 to 71 with an average of 21. In two of the experiments [5B (1937); 5D (1937)] two adults of *S. e. emarginata* infected with *C. laruei* and *C. emarginatae* respectively had larger numbers of metacercariae (261 and 467) than any of the much larger specimens of *L. stagnalis* in the same experiments.

It also can be seen from Table 6 [5B (1937); 5D (1937); 5E (1937)] that adults of *S. e. angulata* infected with the schistosome, *C. stagnicolae,* after exposure to the cercariae of *C. flabelliformis* from *L. stagnalis,* had much larger numbers of metacercariae than the uninfected snails of the same species in the same experiments. While the number of snails in the experiments infected with this schistosome is small, the results are consistent and the differences are considerable. The nine snails infected with *C. stagnicolae* had numbers of metacercariae ranging from 17 to 82 with

TABLE 6.—A summary of the counts of metacercariae in experiments in which uninfected and infected adults of *S. e. angulata* were exposed to the cercariae of *C. flabelliformis* that had developed in *L. stagnalis*. A few specimens of *L. stagnalis* were placed in each of these experiments as controls of the extent of exposure to the cercariae.

Control examinations were made as follows for previously acquired natural infections with the metacercariae of *C. flabelliformis* of snails from the same collections as those used in these experiments:

13 (1935): 15 *L. stagnalis*, negative; *S. e. angulata*, no examinations, but no suggestion of previous infection from experimental results.

5B, C, D, E, (1937): 50 *L. stagnalis*, 47 negative, 3 positive with a total of 5 "cysts"; 23 *S. e. angulata*, 22 negative, 1 positive with 1 "cyst."

Exper. No.	Days from infection to examination	Larval trematode infection in experimental snails	Data from metacercarial counts						
			No. of snails	No. pos. for metacercariae	Range in no.	Av. no.	% "cysts"	% "precysts"	% "developing"
13 (1935)	14–17	*L. stagnalis*—uninfected	3	3	166–394	283	10.6	89.4	
	"	*S. e. angulata*—uninfected	11	11	1–71	24	6.4	5.7	87.9
	"	*S. e. angulata*—*C. emarginatae*	3	3	45–102	79	0.8	98.2	0.0
	"	*S. e. angulata*—*C. yogena*	2	2	53 & 56	...	63.3	36.7	0.0
5B (1937)	18–19	*L. stagnalis*—uninfected	6	6	18–240	103	14.5	27.9	67.6
	"	*S. e. angulata*—uninfected	10	10	3–51	22	48.4	30.9	20.7
	"	*S. e. angulata*—*C. emarginatae*	2	2	109 & 111	...	29.5	70.5	0.0
	"	*S. e. angulata*—*C. laruei*	2	2	97 & 261	...	64.4	32.3	0.3
	"	*S. e. angulata*—*C. yogena*	2	2	11 & 107	...	61.1	34.7	4.2
	"	*S. e. angulata*—*C. stagnicolae*	2	2	58 & 65	...	25.2	71.5	3.3
	"	*S. e. angulata*—*D. flexicaudum*	4	2	0–6	4	50.0	50.0	0.0
5C (1937)	26–27	*L. stagnalis*—uninfected	3	3	59–158	98	74.6	22.0	3.4
	"	*S. e. angulata*—uninfected	5	5	3–55	21	21.9	41.9	36.2
	"	*S. e. angulata*—*D. flexicaudum*	5	4	1–4	1	70.0	30.0	0.0
	"	*S. e. angulata*—*P. muris*	6	4	0–29	7	97.5	0.0	2.5
5D (1937)	22–25	*L. stagnalis*—uninfected	6	6	75–172	104	59.2	30.1	10.7
	"	*S. e. angulata*—uninfected	8	8	1–47	23	38.7	25.7	35.6
	"	*S. e. angulata*—*C. emarginatae*	3	3	34–467	207	92.4	0.8	6.8
	"	*S. e. angulata*—*C. stagnicolae*	3	3	17–82	68	72.8	20.0	5.2
	"	*S. e. angulata*—*P. muris*	8	4	0–19	4	91.4	8.6	0.0
5E (1937)	21–22	*L. stagnalis*—uninfected	4	4	103–221	147	46.6	28.6	24.8
	"	*S. e. angulata*—uninfected	4	4	1–6	4	57.2	35.7	7.1
	"	*S. e. angulata*—*C. emarginatae*	3	3	24–183	78	80.4	17.0	2.6
	"	*S. e. angulata*—*C. stagnicolae*	4	4	25–52	34	68.4	30.9	0.7

an average of 51, while the 22 uninfected specimens of *S. e. angulata* in the same experiments had numbers ranging from 1 to 51 with an average of 19.

In three of the experiments summarized in Table 6 there were included adults of *S. e. angulata* infected with the germinal sacs of *D. flexicaudum* and *P. muris* [5B (1937); 5C (1937); 5D (1937)]. The snails parasitized by these two trematode species had very few metacercariae. In fact, the numbers were so small that it appeared as if the presence of these two trematodes had definitely decreased the susceptibility of the snails to the infection with the cercariae of *C. flabelliformis* from *L. stagnalis*. However, the evidence given above clearly shows that parasitism with the other four larval trematodes (*C. emarginatae, C. yogena, C. laruei* and *C. stagnicolae*) had definitely increased the susceptibility of the snails to this variety of *C. flabelliformis*.

DISCUSSION

One of the most interesting of the second intermediate host relationships of *C. flabelliformis* is the development of its metacercariae inside the germinal sacs of the trematode parasites of the snails serving as second intermediate hosts. In this location they are able to develop as hyperparasites cut off completely from the host's tissues. That they find the food substances absorbed by the germinal sacs very suitable for their nutrition is shown by their rapid development to the encysted stage. The presence of strigeid metacercariae inside sporocysts and rediae of other trematode parasites was described and figured by some of the earliest observers on larval trematodes. Such a relation is characteristic of the few strigeid species that normally utilize snails as second intermediate hosts. It is a true hyperparasitism of one species of parasite inside of another. It, therefore, is quite a different relation from those much more numerous cases in which trematode cercariae precociously develop into metacercariae without leaving their own germinal sacs (Cort and Brackett, 1937a; McMullen, 1938a). As noted above, the metacercariae of *C. flabelliformis* practically always develop more rapidly as hyperparasites inside the germinal sacs of trematodes than in their normal location in unparasitized snails. This has been repeatedly observed, both in normal and abnormal hosts, whenever the experiments permitted comparisons.

As brought out in the experiments, the presence of the germinal sacs of trematodes in snails influences in several different ways their second intermediate host relations to *C. flabelliformis*. In the first place, when snails are infected with the sporocysts and developing cercariae of *C. flabelliformis*, they are almost completely protected against the development of its metacercariae. This relation seems to be a specific immunity produced by one stage of a parasite against a later stage. In the second place, normal second intermediate hosts of *C. flabelliformis* are protected against the development of its metacercariae by the presence of the germinal sacs and developing cercariae of certain other trematode species. This relation might be considered as a nonspecific immunity produced in the snails by the presence of these parasites. In the third place, the presence of certain species of larval trematodes permits the development of the metacercariae of *C. flabelliformis* in snails that are entirely or partially unsuitable second intermediate hosts for this species of trematode. Finally, the presence of certain particular species of larval trematode parasites produced both a nonspecific immunity in normal second intermediate hosts and also increased the susceptibility in abnormal hosts. Further discussion of these relations follows.

Specific immunity.—Perhaps most striking of all is the protection which the sporocysts and developing cercariae of *C. flabelliformis* gives the infected snails against its own metacercarial stage. As already stated, this appears to be a specific immunity produced in the snail host by one stage of the parasite's life cycle that protects it against a later stage. This immunity is not absolute since a very few metacercariae do develop normally inside the sporocysts. What happens is that when a snail infected with the sporocysts of *C. flabelliformis* is exposed to the cercariae of this same species, most of them do not penetrate at all. Their reactions in such exposures have been observed under a low-power binocular microscope. When the cercariae of *C. flabelliformis* came into contact with the body surfaces of specimens of *L. stagnalis* infected with the sporocysts of the same species, they reacted entirely differently from those that came into contact with uninfected controls (Winfield, 1932; Cort and Nolf, 1933). In the case of the infected snails, the cercariae moved along the surface with a looping movement and soon swam away. With the uninfected snails they started to penetrate almost immediately on making contact, and soon their bodies disappeared into the snail's tissue leaving behind only their detached tails. This shows that the specific immunity produced by the presence of the sporocysts and developing cercariae of *C. flabelliformis* in some way prevents most of the cercariae of this species from penetrating into the infected snails. Penetration of the cercariae of *C. flabelliformis* into snails is not a host specific phenomenon since they penetrate readily into abnormal second intermediate hosts. Also, there is not the slightest evidence that suitable second intermediate hosts exert any attraction for the cercariae as is the case with the intermediate hosts for the miracidia. Therefore, the specific immunity which prevents the penetration of the cercariae must be caused by some change, probably chemical, in the tissues of the snail, produced by the presence of the sporocysts and developing cercariae of *C. flabelliformis,* which actually repels the cercariae of this species when they make contact.

Nonspecific immunity.—In snails that are normal second intermediate hosts for *C. flabelliformis,* the presence of the germinal sacs of certain trematode species is associated with a great reduction in the numbers of metacercariae that develop. Although our evidence is not conclusive, this reduction in numbers of metacercariae in most cases seems to be due to the presence in the snails infected with these larval trematode species of some sort of a nonspecific immunity that prevents the penetration of the cercariae. Like the specific immunity produced by the presence of the sporocysts of *C. flabelliformis,* this nonspecific immunity is not absolute since a small proportion of the cercariae were able to penetrate and develop normally into encysted metacercariae inside the germinal sacs.

Of the trematode species that produce this nonspecific immunity the relations of *D. flexicaudum* are particularly interesting. The presence of the sporocysts of this trematode in specimens of *S. emarginata* in experiments produced a definite nonspecific immunity to the cercariae of *C. flabelliformis* from this host (Table 3). When, however, snails of this species infected with *D. flexicaudum* had long continued heavy exposure to the cercariae of this variety under natural conditions, large numbers of metacercariae developed in most of them, indicating that the nonspecific immunity was broken down (Table 2).

Of the other species of larval trematodes that produce nonspecific immunity in normal second intermediate hosts, we were able to obtain the most extensive infor-

mation on *P. muris*. Specimens of *S. emarginata* infected with the sporocysts of this trematode had only a few metacercariae when exposed to long continued natural infection (Table 2) with the cercariae of *C. flabelliformis* from the same snail species. Also, 65 snails of the same species, infected with the larval stages of this species of trematode showed without exception the same type of resistance when exposed in three different experiments (Table 3) to the cercariae of *C. flabelliformis* from *S. emarginata*. The evidence of nonspecific immunity in individuals of *S. emarginata* infected with the rediae of *E. revolutum* also rests both on their resistance to natural and experimental exposure to the cercariae. The evidence for a nonspecific immunity produced by infections with *P. micranthos* and *C. stagnicolae* in *S. emarginata* and by *C. talboti* and the unidentified echinostome in *S. p. elodes* in each case comes from a single experiment. In each of these cases, however, the differences in numbers of metacercariae between the snails infected with these trematodes and the uninfected groups were very striking.

In all these instances of nonspecific immunity to the metacercarial stages of *C. flabelliformis* produced by infections with the species of trematodes listed above, the numbers of metacercariae were greatly reduced but the few that got into the germinal sacs developed normally. Our view in regard to the mechanism of this non-specific immunity is that it is probably similar to that of the specific immunity produced by infections with the sporocysts of *C. flabelliformis*. There appears to be a great reduction in the numbers of cercariae of *C. flabelliformis* that penetrate into the snails infected with these particular species of larval trematodes, produced perhaps by some chemical change that repels the cercariae.

It is evident, also, that the nonspecific immunity produced against the penetration of the cercariae of *C. flabelliformis* by the presence of certain species of larval trematodes in normal second intermediate hosts is a species and not a group reaction. It was produced by the presence of three plagiorchiid species, *P. muris, P. micracanthos* and *C. talboti,* but not by another closely related species, *P. proximus;* and it was produced by only one, *D. flexicaudum,* of several species of strigeids that were present in the snails in the experiments.

Increased susceptibility of abnormal hosts produced by larval trematode infections.—When snails are abnormal second intermediate hosts for *C. flabelliformis* the presence of larval trematode infections produces an entirely different effect from that discussed above in normal hosts. A discussion of this relation in physid and planorbid snails has already been published (Cort, Olivier, and Brackett, 1941). When physid and planorbid snails were not parasitized by larval trematodes and were exposed to the cercariae of *C. flabelliformis,* they penetrated in large numbers, but except in a very few, and perhaps questionable instances, did not even start to develop. When, however, larval trematode infections were present, large numbers of the cercariae were able to penetrate into their germinal sacs and develop normally to the encysted metacercarial stage. It was suggested that when the bodies of the cercariae that penetrate into abnormal hosts are able to get into the sporocysts or rediae of the trematode parasites, they are protected from any immune reactions of the abnormal hosts tissues, and find very satisfactory for their nutrition the food material which has been absorbed by the germinal sacs and prepared for the nourishment of their own progeny. Thus the presence of the germinal sacs of trematode parasites permits *C. flabelliformis* to use these abnormal snail hosts for the development of its metacercariae and greatly extends its range of second intermediate hosts.

The discovery that *L. stagnalis* is a distinctly abnormal host for the variety of *C. flabelliformis,* the cercariae of which develop in *S. emarginata,* gave a chance to see whether in this host the presence of larval trematodes would permit the development of the metacercariae of this variety. In one experiment it was found that almost no development of metacercariae occurred in snails of this species infected with the sporocysts of *S. douthitti,* while in those infected with the sporocysts of *D. flexicaudum* a considerable number of the metacercariae developed normally inside the germinal sacs. We can give no explanation for the difference in the results with these two parasites. The presence of the sporocysts of *S. douthitti* was found in earlier experiments (Nolf and Cort, 1933; Tables 4 and 5) to interfere with the normal development in *L. stagnalis* of the cercariae of *C. flabelliformis* of the variety from *L. stagnalis.*

As noted above (Table 5) juveniles of *S. emarginata* are distinctly abnormal second intermediate hosts for the variety of *C. flabelliformis* the cercariae of which develop in *L. stagnalis.* There was evidence from the experiments that the cercariae of this variety penetrated into the juveniles, just as they did into physid and planorbid snails, but were unable to develop normally. When, however, the juveniles of this species were infected with larval trematode parasites (Table 4) large numbers of metacercariae developed normally inside the germinal sacs. It can be seen from Table 5 that except for one snail infected with the sporocysts of *P. proximus,* the larval trematode parasites of this series were either *D. flexicaudum* or *P. muris.* The presence of both these trematode parasites appeared to break down completely the abnormal host resistance of the juveniles of *S. emarginata* since large numbers of metacercariae developed inside their germinal sacs.

As brought out previously, adults of *S. emarginata* appear to have lost a considerable part of the abnormal host resistance which the juveniles of this species exhibit so definitely to the variety of *C. flabelliformis,* the cercariae of which develop in *L. stagnalis.* However, they appear to be somewhat abnormal second intermediate hosts to this variety since when the cercariae of *C. flabelliformis* used to infect them came from *S. emarginata* larger and more consistent infections of metacercariae were produced than when they came from *L. stagnalis* (cf. Tables 3 and 6). Of special interest, therefore, are the experiments showing the effect of larval trematode infections in adults of *S. emarginata* on the numbers of metacercariae that developed when they were exposed to the cercariae of the variety of *C. flabelliformis* from *L. stagnalis.* These experiments show (Table 6) that infections with the sporocysts of four different species of larval trematodes (*C. emarginatae, C. yogena, C. larvei,* and *C. stagnicolae*) definitely increased the susceptibility of adults of this snail species to this variety of *C. flabelliformis,* since the numbers of metacercariae that developed in the infected snails were much greater than in the uninfected snails that had the same exposure to the cercariae. On the other hand, in experiments where the cercariae of *C. flabelliformis* were of the variety that develops in *S. emarginata,* the adults of *S. emarginata* infected with these same species of larval trematodes never had larger numbers of metacercariae than the uninfected snails (Table 3). It is of special interest to point out that adults of *S. emarginata* infected with the sporocysts of *C. flexicaudum* and *P. muris* showed the same nonspecific immunity to the development of the metacercariae of *C. flabelliformis* when the cercariae came from *L. stagnalis* as when they came from *S. emarginata* (cf. Tables 3 and 6).

TABLE 7.—*Summary of the results on the development of the metacercariae of the two varieties of* C. flabelliformis *in lymnaeid snails infected with larval trematodes*

	Uninfected	*C. flabelliformis*	*C. emarginata*	*C. yoyena*	*C. laruei*	*C. macradena*	*D. flexicaudum*	*C. stagnicolae*	*S. douthitti*	*P. proximus*	*P. muris*	*P. micracanthos*	*C. talboti*	*E. revolutum*	Large echinostome
A. Variety of *C. flabelliformis*, the cercariae of which develop in *S. emarginata*															
L. stagnalis	−	..	..	..	..	..	+	..	−	..	..	..	..	..	..
S. emarginata (juveniles)	±	..	..	..	..	..	..	..	..	..	−	..	..	..	..
S. emarginata (adults)	+	−	+	+	+	..	±	−	..	+	−	−	..	−	..
B. Variety of *C flabelliformis*, the cercariae of which develop in *L. stagnalis*															
L. stagnalis	+	−	..	..	..	..	..	..	±	..	..	..	..	..	..
S. palustris elodes	+	..	..	..	..	+	..	..	..	..	..	..	±	..	±
S. emarginata (juveniles)	−	..	..	..	..	..	+	..	..	+	+	..	..	..	..
S. emarginata (adults)	±	..	+	+	+	..	−	+	..	..	−	..	..	..	..

+ = good development; ± = moderate development; − = very little development.

Relations of individual species of larval trematodes.—Table 7 is a very condensed summary of the effects of parasitism with individual species of larval trematodes in the lymnaeid snails included in our experimental studies on the development of the metacercariae of the two varieties of *C. flabelliformis.* It can be seen from this table that the effects of three of the species (*C. flexicaudum, C. stagnicolae* and *P. muris*) are rather complicated and appear to be inconsistent. All three species appear to produce a nonspecific immunity to the development of the metacercariae of *C. flabelliformis* when they are present in snails that are normal second intermediate hosts. In distinctly abnormal hosts (*L. stagnalis* to the variety of *C. flabelliformis* from *S. emarginata* and juveniles of *S. emarginata* to the variety from *L. stagnalis*) the presence of two of them (*C. flexicaudum* and *P. muris*) completely broke down the resistance and allowed large numbers of metacercariae to develop. Finally, in adults of *S. emarginata* which are only slightly abnormal hosts to the variety of *C. flabelliformis* from *L. stagnalis* the presence of two of them (*D. flexicaudum* and *P. muris*) produced an almost complete nonspecific immunity while the presence of the other (*C. stagnicolae*) increased the susceptibility. However, further studies are needed to check the relationship of infections with *C. stagnicolae* since the evidence for its production of nonspecific immunity in a normal host rests on only one experiment including 5 individuals [Table 3, 14 (1935)]. The evidence on the relations of *C. flexicaudum* and *P. muris,* on the other hand, rests on a considerable series of different experiments involving large numbers of individuals. Therefore, it seems possible to conclude that the presence of infections with these two species produces both a specific immunity in normal and slightly abnormal hosts, and also breaks down the abnormal host resistance in distinctly abnormal hosts.

SUMMARY

This paper brings together all the data obtained during the summers of 1932 to 1941 at the University of Michigan Biological Station on the influence of larval trematode infections in lymnaeid snails on their second intermediate host relations to the strigeid trematode, *Cotylurus flabelliformis.* Whenever the cercariae of *C. flabelliformis* are able to get into the germinal sacs of trematodes parasitic in snails the metacercariae develop normally to the encysted stage as hyperparasites. In fact, they develop more rapidly in this location than in their normal habitat, the hermaphroditic gland. In snails infected with the sporocysts of *C. flabelliformis* there is a specific immunity produced against the cercariae of this species which prevents all but a few from penetrating. In other words, snails serving as intermediate hosts for this trematode species cannot serve effectively as second intermediate hosts for the development of its metacercariae. In normal second intermediate hosts the presence of the germinal sacs of certain species of larval trematodes does not affect the numbers of metacercariae that develop. Other species, however, produce in the infected snails a nonspecific immunity which greatly reduces the numbers of metacercariae that develop. Both the specific and the nonspecific immunity in the snails infected with these larval trematodes appear to be caused by some change in the snails that prevents most of the cercariae from penetrating. The few that do get in find their way into the germinal sacs of the trematodes and develop normally.

In snails that are abnormal second intermediate hosts for *C. flabelliformis* the presence of the germinal sacs of larval trematodes tends to break down the resistance

and allows numbers of the metacercariae to develop. In completely abnormal hosts such as physid and planorbid snails the cercariae penetrate but fail to develop unless trematode parasites are present. In the infected snails they penetrate into the germinal sacs and there develop normally. The same relation was found to be true in *L. stagnalis* and *S. emarginata* which are abnormal second intermediate hosts for the varieties of *C. flabelliformis* the cercariae of which develop in *S. emarginata* and *L. stagnalis* respectively. Almost no development of metacercariae takes place in *L. stagnalis* when exposed to infection with the cercariae of *C. flabelliformis* from *S. emarginata.* In snails infected with the sporocysts of *D. flexicaudum,* however, the cercariae of this variety develop in large numbers. Also, almost no development of metacercariae takes place in juveniles of *S. emarginata* when exposed to infection with the cercariae of *C. flabelliformis* from *L. stagnalis.* When, however, the juveniles of this species harbor the sporocysts of certain species of larval trematodes the metacercariae of this variety develop in large numbers. Adults of *S. emarginata,* while much more susceptible than juveniles to the variety of the cercariae of *C. flabelliformis* from *L. stagnalis* still show a degree of abnormality. Infection with certain species of larval trematodes breaks this partial resistance and permits much larger numbers of the metacercariae to develop than in uninfected snails, while the presence of certain other species increases this resistance so that the snails are almost completely immune to the development of the metacercariae. Perhaps most surprising of all was the finding that infections with certain species of larval trematodes (*D. flexicaudum* and *P. muris*) produce nonspecific immunity in normal second intermediate hosts and also increase the susceptibility of abnormal hosts.

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INGESTION PROCESSES ON *IODAMOEBA* (PROTOZOA)

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In discussing the food habits of *Entamoeba muris* and *E. ranarum,* Wenrich (1941) described the presence of differentiated "pharynges" and tubes which appeared to be used in ingestion. In 1943 he described similar structures on a flagellate, *Histomonas meleagridis,* from domestic chickens and pheasants (*Phasianus torquatus*). He recently (1944) noted them on *Dientamoeba fragilis* from man.

The following observations were made on *Iodamoeba* from man and two other primates. These structures were not noted by Wenrich (1937) in his paper on *Iodamoeba bütschlii.*

MATERIAL

The present studies concerned two cases of *Iodamoeba bütschlii* infection in man, and one of *Iodamoeba kueneni* from the chimpanzee. Brief observations were also made on a similar infection in a Guinea baboon, from the Philadelphia Zoölogical Gardens.

The material was fixed in Schaudinn's fluid plus 5 per cent of glacial acetic acid, and stained in Heidenhain's hematoxylin.

Thanks are due Mr. Warren E. Buck of Camden, New Jersey, for the chimpanzee material, and to Dr. D. H. Wenrich who made the slides from this host.

OBSERVATIONS

The tube-like structures found on these organisms varied considerably in size and general morphology. A single amoeba frequently showed those of more than one type. As many as four of these processes were occasionally seen on one organism. Some were quite large (Fig. 1), while others were small. Many were twisted (Figs. 1; 3; 7), others were straight (Figs. 2; 5). There were food objects in some projections (Figs. 1; 2; 5; and lower process on 6), while others were apparently about to engulf them (Figs. 1; 8).

In many projections the walls were not especially darkly stained (Figs. 1; 2; upper process on 4; 5; 8). These appeared to be the more recently formed. In general, those with darkened walls (Figs. 3; lower process on 4; 6; 7) appeared to be contracting or in the process of being resorbed. The lower projection on the amoeba shown in Fig. 6, then, might be a later stage than that figured on 5, where, after the original contact with the food (5), the projection has withdrawn toward the body (6), resulting in more deeply staining walls. The upper left process on Fig. 6 probably represents the last stage in resorption.

There is also some evidence that ingestion may be accomplished by the formation of food cups on the surface of the amoeba.

Counts were made to determine the frequency of these projections. In one case, 300 trophic forms of *Iodamoeba bütschlii* included 35 with processes (11.7 per cent), while in another, 135 out of 500 showed them (27.0 per cent). In 100 individuals of *I. kueneni* (chimpanzee) examined at random, only one possessed a tube (Fig. 8).

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Though showing occasional projections, the material from the Guinea baboon was unsuitable for statistical analysis.

DISCUSSION

The processes herein described on *Iodamoeba* appear to function in an ingestatory capacity. Some would seem to be tube-like, at least in part. They are similar to structures described by Wenrich on *Entamoeba muris* and *E. ranarum* (1941), on *Histomonas meleagridis* (1943), and on *Dientamoeba fragilis* (1944). They are more like those from the amoebae, however, in lacking the dense, deeply-staining core surrounded by a layer of clear ectoplasm, as described in the projections from the flagellate, *Histomonas*. They more nearly resemble the structures on *Histomonas* in the degree to which they may extend from the body proper. For further discussion of function, mode of operation, etc., see the papers by Wenrich.

SUMMARY

1. Both *Iodamoeba bütschlii* from man and *I. kueneni* from the chimpanzee and Guinea baboon may produce tube-like projections some of which, at least, appear to be acting as organs of ingestion.

2. In two cases from man the frequency of the processes was 11.7 and 27.0 per cent respectively.

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DESCRIPTION OF THE PLATE

Figures 1–7 are of *Iodamoeba bütschlii* from man; fig. 8 is *I. kueneni* from the chimpanzee.

FIG. 1. Long, twisted projection, with food objects at either end.

FIG. 2. Amoeba with short projection containing food.

FIG. 3. Note twisted projection with deeply stained areas in the walls, suggesting retraction.

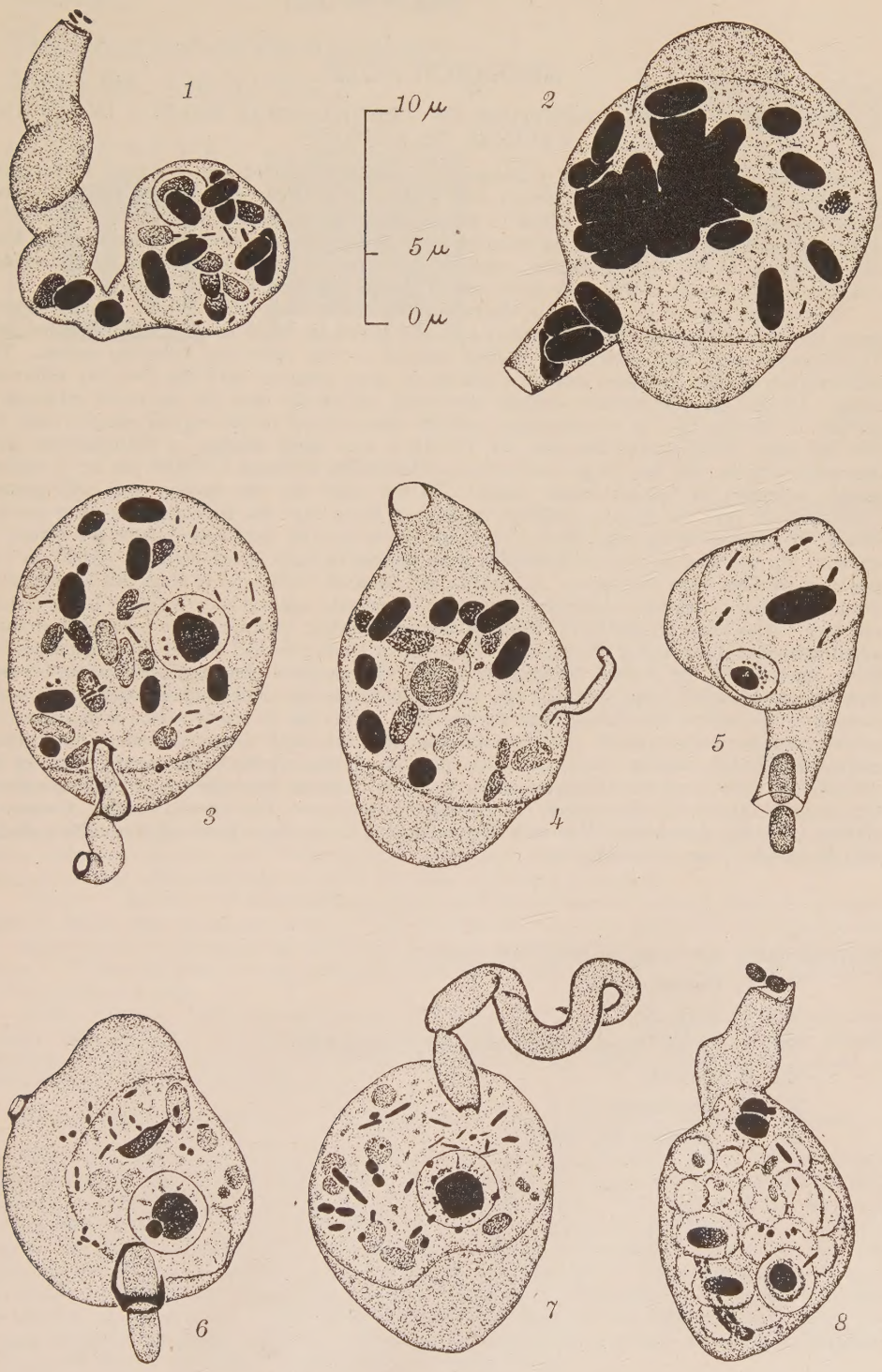
FIG. 4. Upper projection appears freshly formed and tube-like at end; lower one retracting(?).

FIG. 5. Bacteria in the act of entering the process.

FIG. 6. Upper left projection appears in the last stages of resorption; lower one ingesting, and also withdrawing(?).

FIG. 7. Long, twisted process, thick-walled and retracting(?).

FIG. 8. Process appearing to be at the moment of ingestion. (Slide courtesy of Dr. D. H. Wenrich.)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RESEARCH NOTE

AN INSTANCE OF PHAGOCYTOSIS OF *TRICHOMONAS FOETUS* IN BOVINE VAGINAL SECRETIONS

Wenrich and Emmerson (1933, J. Morph. **55**: 193–205) reported that in stained preparations of vaginal discharge from a cow infected with *Trichomonas foetus* many of the leucocytes contained ingested cellular elements, which in some cases could be identified as ingested flagellates. They suggested that this indicated an activity on the part of the leucocytes in defense of the host. An observation by the present authors, made in the course of daily observations on heifers and cows during the course of their infections with *T. foetus,* supports this viewpoint.

The vaginal sample on which our observation was made was obtained from a heifer undergoing her initial infection; she was bred as a virgin, at the age of 19 months, to an infected bull. Trichomonads were first detected in vaginal samples on the sixth day following coitus. The trichomonads rapidly increased and were present in large numbers until the 26th day following coitus. On that day the numbers suddenly decreased, and on the next day the heifer returned to estrum. Following this, no trichomonads could be demonstrated in the vaginal samples until the 41st day after coitus, except that one day (33rd), a very small number of trichomonads were observed. On the 41st day, large numbers of trichomonads appeared (200,000 per cc of vaginal sample estimated by hemacytometer count); on the 42nd day the number was still greater (2,750,000 per cc). In samples collected on both of these days the trichomonads were moving slowly, in contrast to the high level of activity shown by the organisms before the return to estrum. On the 43rd day the trichomonads were present in much lower numbers (6,000 per cc) and most of them were stationary. In making the count of trichomonads from this sample with the aid of a hemacytometer, a leucocyte containing an actively moving body within a large vacuole was seen. This body, resembling *T. foetus,* performed rotating movements for the period of about a half-hour that it was under observation. Many other leucocytes had similar large vacuoles, but these appeared to be empty of formed matter. There were intermediate stages between these leucocytes with large vacuoles and typical leucocytes in which there were no apparent vacuoles. We believe that the actively moving body within the leucocyte was a trichomonad in process of being phagocytized. On the following six days, until the next estrum, the samples contained widely fluctuating numbers of trichomonads. It appears likely that at this stage of the infection the activity of the leucocytes was a factor in reducing the numbers of trichomonads in the vagina.—Datus M. Hammond and David E. Bartlett, *Zoological Division, Bureau of Animal Industry, Agricultural Research Administration, U. S. Department of Agriculture, Beltsville Research Center, Beltsville, Md.*

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